The Dock and Harbour Authority

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Editorial Comments

The Hartlepools.

It is not often that the name of a port district is in the plural number, and the subject of our leading article and illustrated Supplement this month is probably unique in this regard. Hartlepool and West Hartlepool, respectively a town and county borough in the County of Durham, are in such close proximity as to form practically a single port unit, similar to Liverpool and Bootle, or Manchester and Salford. One is on the North and the other on the South side of Hartlepool Bay, but they are actually contiguous and connected by railway.

The historical side of the port district has already been outlined in an address to the Newcastle Association of the Institution of Civil Engineers by Mr. J. W. Goldson, the Engineer of the Hartlepool Port and Harbour Commission, which appeared in our February issue, but he purposely refrained from dealing with the dock system, which appertains to the London and North Eastern Railway Company. Through the courtesy of the latter, we have since been supplied with the descriptive notice of the docks, which will be found elsewhere in this number.

There are one or two items of interest which perhaps may be added to the information contained in these two articles. The name Hartlepool means the pool, or lake, of Hart, and the first settlement apparently grew up round a monastery, or possibly a nunnery, for St. Hilda is named as Abbess. The harbour was a centre of commerce and shipping of some consequence as early as the year 1171, though, as Mr. Goldson mentioned, there was probably a port of some sort in existence at the time of the Danish occupation.

There is no river entering the bay, but there is, or was, a harbour bar forming an obstruction of sufficient magnitude to require persistent dredging, which has been effective in maintaining a depth of 30-ft. at high water in the entrance channel. The tidal rise is 16-ft. at Springs and 12-ft. at Neaps.

Although, perhaps, to be classed among the minor ports of Great Britain, the Hartlepools enjoy a flourishing import trade in timber and ore, the former mainly for the mining industry and the latter for the service of steelworks in the adjacent district; and an export trade in coal, which at an earlier date was of chief importance, but has latterly somewhat declined in comparison, though it still maintains a good record.

The Port of Hamburg and the Anschluss.

Recent events in Austria have had repercussions in a number of directions, but from a port point of view perhaps one of the most significant is in regard to the economic outlook of the Port of Hamburg, one of the three foremost maritime centres in the North-western region of the Continent of Europe. A considerable amount of Austrian trade had, we learn, been attracted to Hamburg, even before Herr Hitler's dramatic stroke, and it is now confidently anticipated in German shipping circles that the union of the two countries will accentuate this movement and, indeed, bring about an increased turnover in German seaports generally. Hamburg certainly expects to derive an important degree of benefit by the diversion of trade from the Danube to the Elbe.

Another factor in the situation is the law passed by the German Reichstag in January last by which territorial partitioning in the Lower Elbe was abolished and the Prussian ports of Altona and Harburg-Wilhelmsburg were incorporated with the Free State of Hamburg to form one united Port of Hamburg. These developments are bound to have an appreciable effect on the trade and status of the port, which may result in its acquiring a commanding position in competition with its rivals, Antwerp and Rotterdam.

The following statistics will give an idea of the progress made at Hamburg during the past few years. Since 1936, the inward traffic of shipping has shown an increase of 2,042 ships of 693,860 tons net register tonnage, representing 12.5 per cent. increase in number and 3.7 per cent. increase in tonnage. The outward traffic shows approximately the same ratio. As regards goods, there has been an increase of about 7 per cent. over last year's returns, the position being helped by the indifferent grain harvests of last summer, resulting in a rise in the importation of grain by 900,000 tons, principally from Argentina, North America and India.

The situation is interesting, and further developments will be watched with a considerable degree of attention.

Dockside Amenities.

Whatever other association of ideas may be conjured up by the mention of the term Docks, no one would dream of associating them with parks and pleasure spaces. Too often in the past they have been areas of dingy squalor, frequented by drunken sailors and persons of ill-repute. W. W. Jacobs, the distinguished novelist, has done much to invest them with an atmosphere of innocent humour and naive simplicity, but his pictures of quayside taverns and sailing craft, belong rather to the order of imaginary, than of actual, things.

Now, however, the public is beginning to awake to the fact that there is no necessity for the existence of squalid purlieus in the vicinity of docks and the National Union of Seamen has recently been discussing plans for the "cleaning up" of dock areas with the object of protecting seamen from the enticements of evil individuals. These discussions have followed upon the announcement of Mr. Ernest Brown, the Minister of Labour, to a deputation of the Trades Union Congress, that the Government would accept the recommendations for seamen's welfare in ports, made by the International Maritime Conference at Geneva in 1936. These recommendations included the regulation of the sale of intoxicating liquor, the limitation of the sale of narcotics, the prohibition of the employment of "young persons" in public houses, and of the unauthorised entrance of all and sundry to dock and harbour premises. The Government seems disposed to deal with the matter by setting up a central committee composed of shipowners, seamen and "local authorities," presumably including port authorities.

No one will contend that the proposed step is undesirable or superfluous. Anyone who has had occasion to visit areas adjacent to the quayside after dusk in our larger ports, could not fail to do so with a feeling of mistrust and apprehension. The alternations of dim and shadowy silence with the occasional outbreak of a drunken brawl at or near a public house imparted to the neighbourhood an air of sinister significance.

In contrast to this picture of drabness and vice, we have pleasure in recalling the impression produced by a recent visit to the new quay of the Port of Southampton where the Southern Railway have been at pains to form in the rear of the transit sheds and at the docks entrance, stretches of turf and parterres gay with flowers. The reaction in the mind of overseas travellers must be one of unqualified pleasure, and we cordially commend the example of the Railway Company to the authorities of other passenger ports as a useful bit of propaganda.

Editorial Comments—*continued*

A.R.P. Plans for Docks.

A Paper on Defence of Transport against Air Attack, read before the Institute of Transport on March 28th by Wing-Commander E. J. Hodsoll, included at the end, almost as an afterthought, some observations on the protection of docks and dock premises in the event of air raids. The main part of the Paper was taken up with a consideration of the dispositions to be made as regards internal traffic and the public safety generally. Without in any way detracting from the importance of this side of the matter, it would be short-sighted folly not to realise the extreme vulnerability of the country's dock systems, and the disastrous results of a successful attack on port works. For it has to be borne in mind that most ports in this country have extensive impounded areas of water within which vessels remain afloat at times when there is insufficient depth in the outer waterway for this purpose. The effect of a direct hit on a pair of dock gates would be, in all probability, the release of a great flood of water, causing widespread havoc and destruction to shipping in the dock and its vicinity. Experience has shown in the past the serious consequences which may ensue from a mishap to the gates at a dock entrance. It is true that most, if not nearly all, docks are provided with lock entrances, comprising, at least, two pairs of gates, but occasions frequently arise in connection with locking and sluicing operations when only a single pair is in position to retain the internal water. The responsibility of maintaining the means of closure intact is, therefore, very great.

It is announced in the press that a special department of the Ministry of Transport has been formed to co-ordinate protective measures in regard to the country's communications, including docks, harbours and canals, as well as railways, road transport and electricity supplies. It is to be hoped that special attention will be given to the protection of port areas since they constitute key positions in regard to the obtainment of supplies from overseas. The Port of London Authority have already prepared a comprehensive programme of precautionary measures. Their plans, designed to ensure, so far as possible, minimum interruption to the handling of important goods in war-time, cover vital points in the five docks systems of the port and provide certain safeguards for ships in the docks and in the river. Splinter-proof and gas-proof shelters for clerical and manual workers at the docks are to be built. There will be a first-aid post and cleansing station within five minutes' walk of any part of the docks. The local fire-fighting services are to be augmented and rescue and emergency repair gangs organised.

The Association of Public Wharfingers of the port have prepared an air raid precautionary scheme on similar lines for application to the riverside public wharves and warehouses.

There is a suggestion that certain ports may have to be closed and shipping transferred to other points. Unless this be an imperative necessity, it will no doubt be avoided as causing serious dislocation of established routes of internal traffic, which may be difficult to replace.

Thames Barrage Scheme.

The sudden and dramatic termination of the preparations for the Public Inquiry by the Port of London Authority into the proposed scheme or schemes for the construction of a barrage across the Thames left, it must be admitted, a sense of disappointment and regret in the minds of a number of people in the general public, who felt that the action of the Government in vetoing any project of this nature by reason of objections to it from the standpoint of national defence, had prevented an investigation of the proposal "on its merits." Whatever these merits may have been, they were not of a practical kind: the step taken by the Government was simply the expression of a fundamental objection which put the whole matter out of court. As regards other considerations, navigation, sanitation, traffic and the rest, we are convinced that an inquiry would have proved the utter impractibility of a project which captivated the imagination of a few enthusiasts, who seem to have pictured the public disporting themselves on an inland lake and sailing toy yachts on a larger edition of the Round Pond in Kensington Gardens. Opposition was expressed to the scheme in unmistakeable terms, not only by the Port Authority, but by the London County Council, the Metropolitan Water Board and other public bodies, whose services and interests would have been vitally affected. We have summarised in a previous issue a few of the obvious difficulties which would have been entailed in carrying on the work of the port, and it is difficult to understand that the scheme could possibly have been proceeded with. Moreover, no one made any suggestion as to how it was to be financed, or how the five millions or so of capital expenditure was to be recouped. Altogether, it belongs to the order of visionary things which should be allowed to dissipate in thin air.

Apparently, however, the Thames Barrage Association do not share this view and they, very unwisely we think, have decided to press the Committee for Imperial Defence to reconsider their decision. What answer they expect to get is a matter for conjecture, but it seems sufficiently obvious that where the national interests are at stake no concession can be made to private enterprises conflicting with those interests, however plausibly supported. Judging from a statement attributed to their Chairman, the Association seems to be convinced that the Port of London Authority is a malign genius exercising an evil spell over the Committee of Imperial Defence. This is an unreasoning attitude which does not redound to the credit of the Association, and will not further their cause in the minds of the public.

North Sea Storm Surges.

In connection with certain abnormal tidal peaks which have occurred in the Thames within recent years, a theory has been put forward in scientific circles that they are due in part to the incidence of "storm surges" in the North Sea, and as the theory is supported by the authorities in charge of the Tidal Institute of the Liverpool Observatory, it has been felt desirable in various quarters that an investigation should be made into the matter with a view to determining how far the theory is correct. In particular, the London County Council, voicing a recommendation of their Main Drainage Committee, as also of the Fire Brigade, have urged the Minister of Health to promote such an investigation by reason of the menace of tidal flooding to the safety and welfare of low-lying districts bordering on the Thames. The Ministry, however, have not seen fit to adopt the suggestion, and now there seems every probability that the Council itself will undertake the necessary research, through the medium of the Tidal Institute, who have offered to carry out a series of observations extending over a period of four or five years for the sum of £1,100. It is understood that the Port of London Authority will assist in supporting the scheme financially, as also, possibly, the Catchment Boards and the County Councils of Kent and Essex. The outlay is not excessive in view of the important issues involved, and if the observations serve to establish the "probability, frequency and amplitude" of the surges, a useful piece of work will have been performed.

Maritime Engineering Research.

The issue by the Institution of Civil Engineers of a report covering the years 1935-37 calls attention to a useful programme of work being carried on in a field, part of which is of undoubted interest to port engineers. The Research Committee of the Institution was constituted by the Council in February, 1935, and was given wide terms of reference with the intention of avoiding exclusion of any branch of engineering which might derive benefit from investigation.

The researches undertaken have comprised five main divisions, of which those most directly affecting dock and harbour practice are Soil Mechanics (Earth Pressures and Pile Driving) and Hydraulics (Waves Pressures).

As regards Earth Pressures with their influence on quay walls and other retaining works, investigation is being carried on into the mechanical properties of soils, more particularly as regards the settlement of structures and the stability of embankments. Pile-driving, especially the driving of reinforced concrete piles, has received consideration in earlier years, and further work is now being prosecuted in connection with certain practical suggestions for the improvement of pile-driving practice.

Wave Pressures is a subject which has attracted considerable attention among engineers abroad, as is evidenced by the article in this issue on the researches of Monsieur Larras. Relatively little has been done in this field by British Engineers, and the account of Monsieur Larras' work will be read with interest.

Lloyd's Register Shipbuilding Returns.

"The statistics issued by Lloyd's Register of Shipping regarding merchant vessels under construction at the end of March last, show that in Great Britain and Ireland there is a decrease of 35,349 tons in the work in hand as compared with the figures for the previous quarter." This statement extracted from the latest quarterly circular issued by Lloyd's Register, gives occasion for some reflection if read in the light of the fairly widespread challenge made in shipping circles to the optimistic view expressed by the Minister for the Co-ordination of Defence, and referred to in the editorial comments of our last issue. Sir Thomas Inskip was apparently satisfied that all was well with the British Mercantile Marine, and that it was adequate to any calls which might be made upon it in war-time. We drew attention to the fact that the present gross tonnage of the British cargo and passenger fleet is several millions less than in 1914. And now comes the announcement that instead of an increment in British shipbuilding, there is actually a falling-off.

It is only fair to add the remainder of the paragraph from which our extract is taken. It reads as follows: "The present total of tonnage under construction—1,089,077 tons—is, however, greater by 74,623 tons than the tonnage which was being built at the end of March, 1937. It is, moreover, very considerably in excess of the aggregate tonnage now under construction in the three leading countries abroad." From this antithetical summary, we must leave our readers to form their own conclusions.

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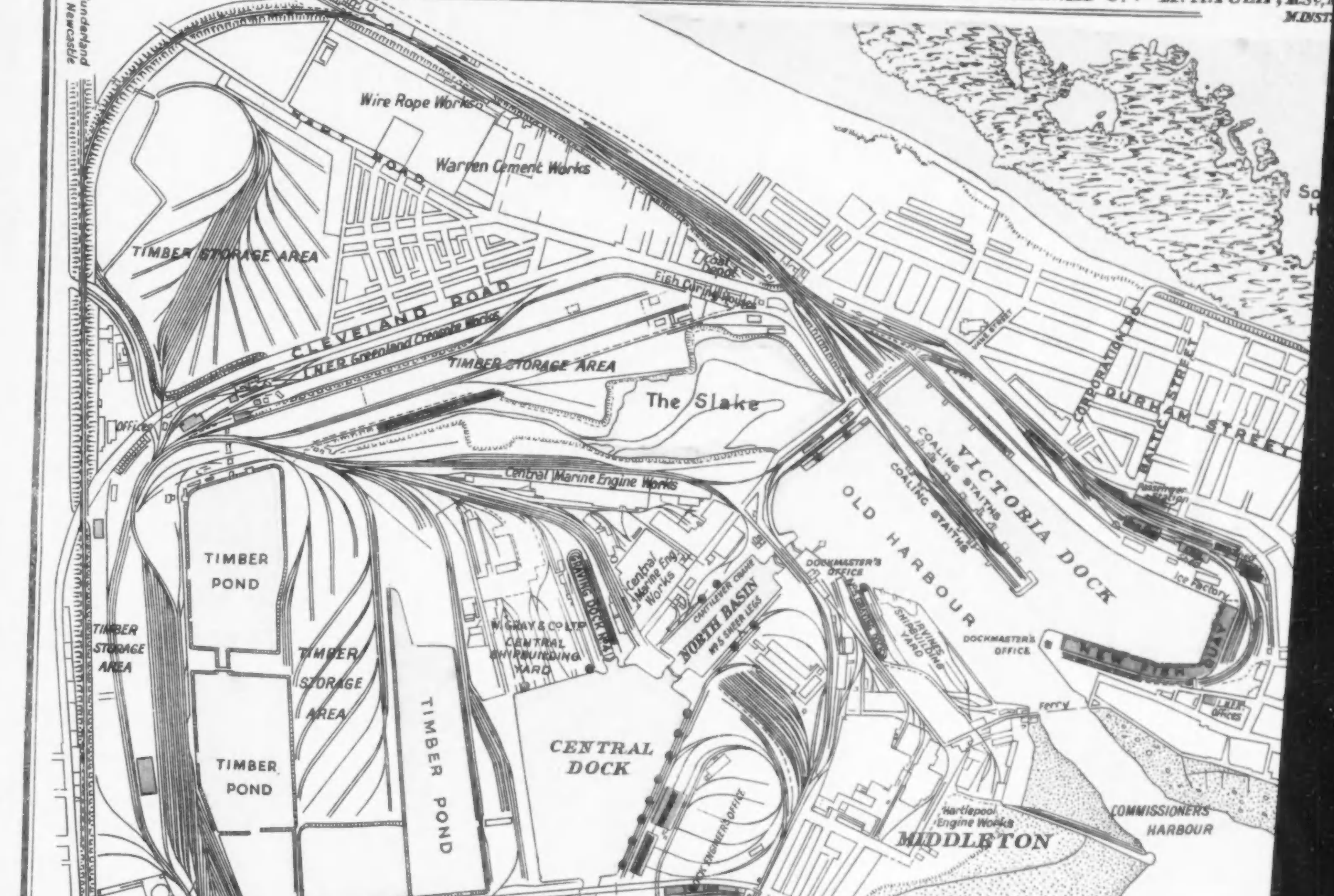
HARTLEPOOLS DOCKS

CHIEF ENGINEER FOR DOCKS TO THE LONDON & NORTH EASTERN RAILWAY Co.:—Mr. A. TULIP, M.Sc., M.INST.



K AND HARBOUR AUTHORITY, MAY, 1938.

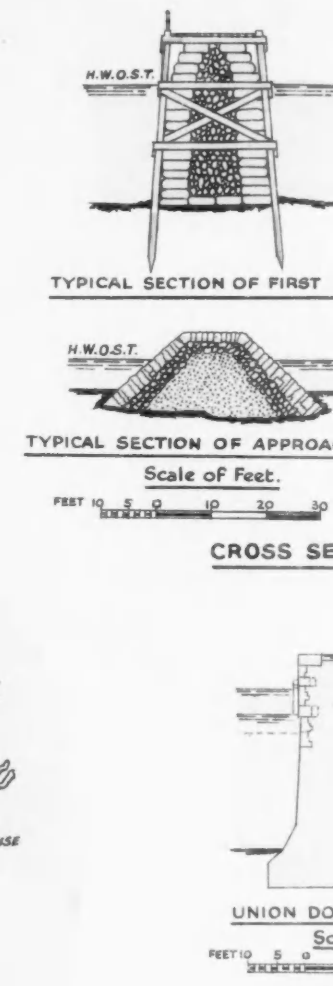
CKS.

.TULIP, M.SC., M.INST.C.E., M.INST.M.E., F.G.S..

Warehouses, Sheds, Stations & Offices coloured RED.

Scale of Feet.

500 1000 1500 2000 2500 FEET



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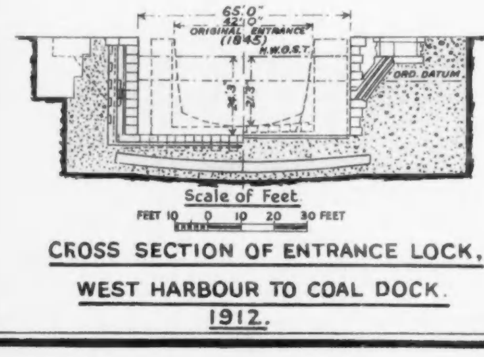

Scale of Feet.

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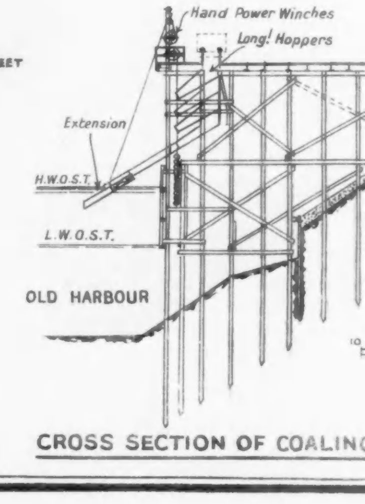
CROSS SECTION OF ENTRANCE LOCK,

WEST HARBOUR TO COAL DOCK.

1912.



CROSS SECTION OF COALING

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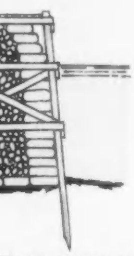

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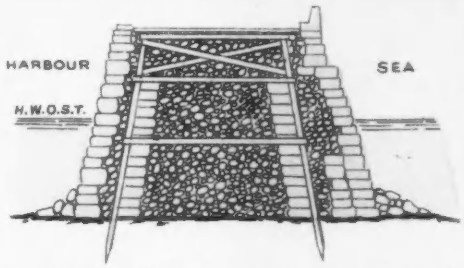
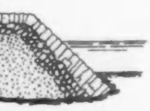


NORMAL SECTION OF EXISTING NORTH PIER.



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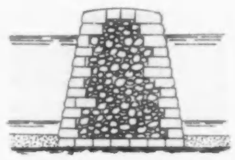
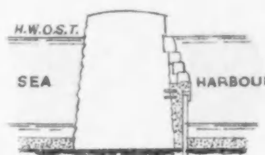
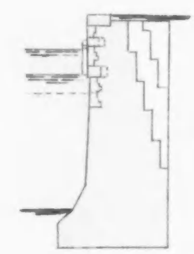


TYPICAL SECTION OF PIERS.



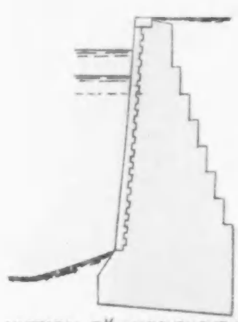
REPAIRS TO OUTER END OF NORTH PIER.

CROSS SECTIONS OF PIERS.



UNION DOCK 1890

CENTRAL DOCK 1880



VICTORIA D^K IMPROVEMENT 1910

Scale of Feet.

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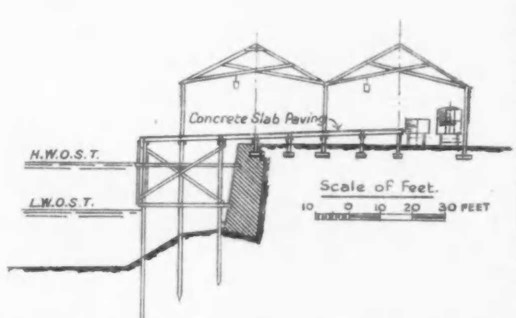
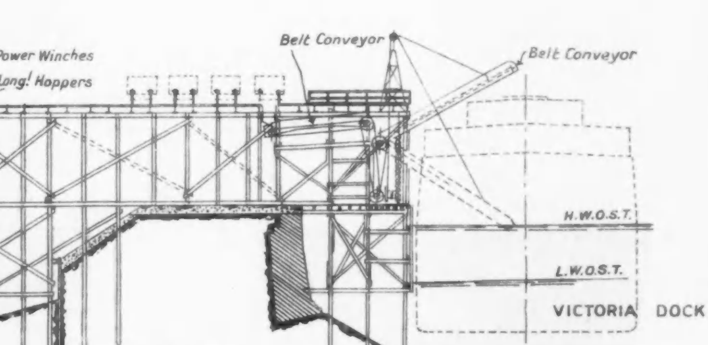
CROSS SECTIONS OF DOCK WALLS.



CROSS SECTION OF FISH QUAY–VICTORIA D^K



OF COALING STAITHES – VICTORIA DOCK & OLD HARBOUR.

The Hartlepools

A Notable Joint Port District on the North-East Coast

(CONTRIBUTED)

Introductory

THE port known as the Hartlepools, which comprises the harbour and tidal dock within the ancient Borough of Hartlepool and the system of enclosed docks at the more modern town of West Hartlepool, is situated in the County of Durham, a few miles North of the mouth of the River Tees, in latitude 52° 42′ North, longitude 1° 11′ West.

The port, originally a small fishing harbour protected on the North and East by a rocky promontory known as the Heugh, owes its modern development to its proximity to the South-East Durham coalfield, for which it is the natural outlet and the export of coal is, of course, one of its principal trades. On the import side timber is the staple traffic, and it is perhaps as a timber port that it is most widely known.

General View of Union Dock showing "C" Jetty on left. In centre is the Entrance from Central Dock spanned by Swing Bridge.

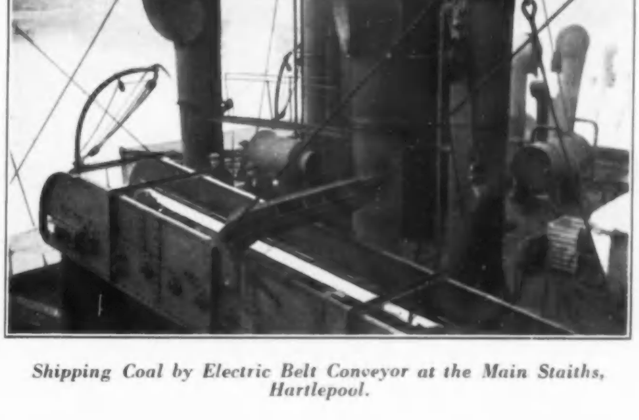
Historical

As a seaport Hartlepool is of very considerable antiquity, and it is apparent that some kind of a harbour existed as long ago as the 12th century. It is recorded that towards the end of the 13th century, Robert de Brus (later King of Scotland and the victor of Bannockburn) " builded the haven and wall about the town of Hartlepool with ten towers on each side of the haven, and a chayne to be drawne between them near the haven, which haven would hold an hundred sayle." The town continued to figure in history right up to the time of the Civil War, and was clearly of some importance. A description of the place in 1832, however, makes it evident that by then the port had become almost derelict, and it was only as a result of the development of the coal trade and the coming of the railway that a revival took place and the modern development of the port began.

The project of a railway to Hartlepool and for coal drops at that point was first put forward in 1823, but it was not until 1831 that active steps were taken and the Hartlepool Dock and Railway Company formed. This Company's Bill received the royal assent on the 1st June, 1832, by which time the original plans for the dock and railway had been modified owing to lack of funds. The execution of the work connected with the excavation of the tidal harbour and the Victoria Dock presented many difficulties, and various modifications in the original plans had to be made. In addition to the natural obstacles encountered, it is recorded that on two occasions work was held up by riots which broke out amongst the English and Irish labourers. The railway to Thornley necessitated the building of a large embankment about two miles long and 30-ft. in height immediately to the north of Hartlepool, and this was largely constructed from spoil excavated from the dock and tidal harbour.

In spite of the many difficulties, work went on apace and on July 9th, 1835, the first cargo of coal—230 tons—from Thornley Colliery, was shipped in the " Brittania," a Sunderland vessel which, we are told " proceeded to sea amidst the ringing of bells, the firing of cannon and the acclamations of the spectators."

The Victoria Dock, which adjoins the Old Harbour, was opened at the end of 1840, and early in the following year the railway from Stockton to Hartlepool was opened. An agreement had been entered into in 1838 between the Dock Company and the Stockton and Hartlepool Railway Company, and it was due to the failure of the traffic to reach expectations, a result which the Railway Company attributed to the difficulties placed in their way by the Dock Company that the project of constructing a separate system of docks was conceived, and accordingly an Act was passed in 1844 authorising their construction. In 1847, what is now known as the Coal Dock, was opened with a separate entrance from the sea, and the West Hartlepool docks were further extended in 1852 and 1856 by the opening of the Jackson Dock and the Swainson and Timber Docks. It was to the establishment of the new system of docks that West Hartlepool owed its existence, and the town grew up round the village of Stranton, on what had previously been practically waste land.



Shipping Coal by Electric Belt Conveyor at the Main Staiths, Hartlepool.

The Hartlepools—*continued*

The entrance to the new system of docks was by no means as well protected as the Hartlepool entrance, and it was therefore necessary to construct an elaborate system of breakwaters to protect it. As will be seen from the Illustrated Supplement, these works are of a somewhat unusual design, inner and outer breakwaters being constructed so that heavy seas running into the harbour mouth are deflected and prevented from beating direct on to the dock gates.

In 1865, the then North-Eastern Railway (now part of the L. & N. E. R. system) acquired the whole of the dock undertaking, which since then has remained in railway ownership, and in 1880 the connecting link between Hartlepool and West Hartlepool, consisting of the Union and Central Docks and the North Basin, was opened. Subsequent developments have included the opening out of the Victoria Dock, which is now a tidal basin, and the construction therein of an up-to-date fish quay accessible at all states of the tide. A lightening berth has also been provided in the Old Harbour with two 3-ton electric cranes to enable vessels whose draft prevents their going immediately to the normal discharging berths in the Central or Union Docks to commence discharge at a deep water quay.

Union Dock "C" Jetty showing vessel discharging Scrap Iron by Grab.

Description of Present Lay-out and Facilities

As will be seen from the Illustrated Supplement, the dock system at the Hartlepools extends in a south-westerly direction from the Victoria Dock in the North to the Swainson and Timber Docks in the South, a total distance of approximately a mile.

Victoria Dock and Old Harbour

The Victoria Dock, which, since the removal of the gates and the widening of the entrance in 1910, has been a tidal basin, has a water area of 17 acres and is devoted mainly to the accommodation of vessels loading coal, and to the fishing industry. The South-East end of the dock is laid out as a commodious covered fish quay and fish market. The depth alongside is 18-ft. L.W.O.S.T., and the quay is therefore accessible by fishing vessels at all times. On the jetty dividing the Victoria Dock from the Old Harbour are situated the main coaling staiths, completed in 1909, to replace the old coal drops. It is here that the bulk of the coal shipped at the port is dealt with. Two berths are provided on each side of these high-level staiths, those on the Victoria Dock side being equipped each with two electric belt conveyors. The two berths on the Old Harbour side have similar appliances with the addition of two gravity spouts at each berth. There is a further staith on the North-East quay of the Victoria Dock. This is largely used for the bunkering of trawlers and other fishing vessels, but larger steamers can also be dealt with. The equipment consists of three gravity spouts. On the Old Harbour side of the main staiths the depth of water available at L.W.O.S.T. is 24-ft., 21-ft. being available at the Victoria Dock side. It is therefore possible to deal with vessels of up to 9,000 tons capacity at Hartlepool. The bulk of the trade, however, is carried on in much smaller ships, for which there is ample water at all states of the tide.

At the North-West end of the Old Harbour is situated the lightening berth, known as the Old Fish Quay. The depth of water available at this quay is 24-ft. at L.W.O.S.T. and the equipment consists of two 3-ton electric travelling cranes with the necessary railway sidings for dealing with traffic discharged from vessels which require to be lightened before proceeding to West Hartlepool. Whilst primarily intended to be used as a lightening berth, the Old Fish Quay is also used during times of pressure to accommodate vessels for which no ready berth is available at the normal discharging points in the docks, and it is therefore a most useful adjunct to the equipment of the port.

The Western side of the Old Harbour is occupied by Messrs. Irvine's Shipyard, with its graving dock measuring 363-ft. by 48-ft. This yard is now largely devoted to ship repairing work.

North Basin

From the Old Harbour a 70-ft. lock gives access to the North Basin, which is in fact a small dock, approximately 630-ft. in length by about 200-ft. in width. At the Old Harbour end of this basin are two sets of lock gates and at the South or Central Dock end, one pair. The basin can therefore be used to lock vessels in and out of the West Hartlepool docks, but this is not a usual practice owing to the amount of water which is lost in the process. Actually, apart from providing a means of communication between the Old Harbour and the West Hartlepool docks, the North Basin is used almost entirely as a fitting-out basin. The quay on the West side is leased to the Central Marine Engine Works, Ltd., who have on it a 100-ton cantilever crane and an electric travelling crane of 8 tons capacity. It is here that most of the vessels launched from the local yards of Messrs. Wm. Gray & Co. are fitted with engines, and a good deal of repair work is also carried out. The quay on the East side is equipped with hydraulic sheer legs of 100-tons capacity, and a 10-ton electric travelling crane. This quay is a public one, but, in fact, is used almost exclusively by Messrs. Richardsons, Westgarth & Co., Ltd., whose works are near at hand and whose marine engines are well known. It should be added that since 1926 the direct entrance to the West Hartlepool docks via the West Harbour, which required constant dredging to keep it open, and which is very much more exposed than the Hartlepool entrance, has been closed, and the North Basin therefore now provides the only means of access for vessels using these docks. The normal hours during which the gates are open for the passage of vessels are from three hours before to one hour after high water.

S.S. Malvernian at C.M.E.W. Fitting-out Berth, North Basin. 100-ton Electric Cantilever Crane in Background.

Central Dock

Adjoining the North Basin is the Central Dock, with a water area of 15¼ acres. The North side of this dock is occupied by Messrs. William Gray & Company's Central shipbuild-

The Hartlepools—continued

ing yard, with its five slipways, and by No. 4 graving dock. This dry dock, which is equipped with an electric 20-ton travelling crane, has a length of 570-ft., and can take vessels up to 60-ft. in beam. On the East side of the dock is a quay providing three of the discharging berths principally used by vessels with timber cargoes. This quay is equipped with eight hydraulic cranes of from $1\frac{1}{2}$ to 3 tons capacity, and two railway sidings extend along its entire length. The dock is flanked on this side of Nos. 7 and 8 dock warehouses. No. 7 is a one-storey transit shed, now used exclusively for the storage of timber, whilst No. 8, a building of five storeys, is now not very much used owing to the weak state of its foundations, though a limited quantity of sawn wood is housed on the ground floor. The long timber-decked quay on the West side of the dock is suitable for berthing small vessels. The quay on the East side of the dock, 366-ft. in length, has no cranes, and is utilised as space for storage. It is regularly used by small vessels bringing tiles from Belgium, and their cargoes are stored on the quay and despatched from there by rail or road as required.

Jackson Dock

A broad channel leads from the Union Dock into the Jackson and Coal Docks. The former, with a water space of over 13 acres, provides for varying activities. Its North quay, which is really the South side of "A" Jetty, provides accommodation for vessels discharging timber cargoes to the quay, whilst its South side is occupied for the greater part of its length by No. 2 dock warehouse. On the East side is what is known as

General View of Union and Jackson Docks, showing "B" Jetty on right and "A" Jetty Centre.

used by vessels discharging cargoes—chiefly of pit-props—direct to quay. A channel, 30-ft. in width, passing under this quay, gives access to the timber ponds, a description of which is given later in the article under the heading of timber storage facilities. This channel is opened and closed by means of lock gates which can either be operated by hand or worked automatically by the flow of water caused by the tide.

Union Dock

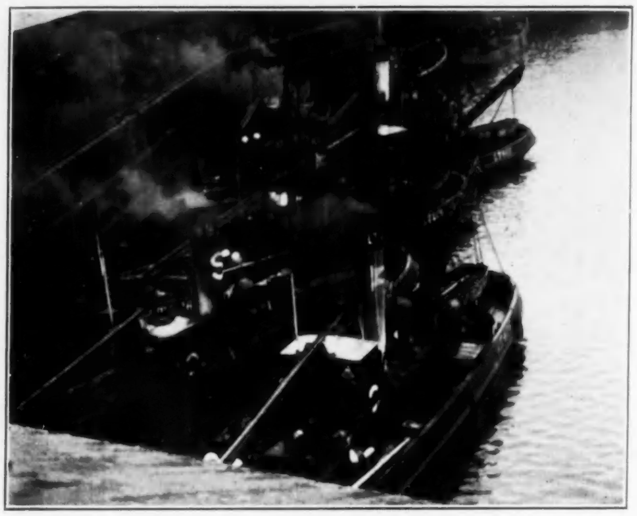
At the South end of the dock is the channel giving access to the Union Dock where the principal discharging berths of the port are situated. Originally the Union, Jackson and Coal docks were each separately enclosed and entered via the West entrance, but they are no longer really separate docks as will be seen from the Illustrated Supplement. The Union Dock has a water space of about 16 acres. On the South side is what is known as "A" Jetty, providing 852-ft. of quay equipped with six 3-ton electric cranes. The North Quay, known as "C" Jetty, is approximately 1,180-ft. in length, and is provided with ten electric cranes, nine of which are of 3-tons capacity and one of 10-tons. Both "A" and "C" Jetties are fully served by railway sidings for the accommodation of wagons being loaded by the cranes and for the standage of both loaded and empty stock. The usual arrangement is for three cranes to be allocated to each vessel so that five ships can normally be berthed at the electric crane berths at "A" and "C" Jetties. The additional crane on "C" Jetty makes it possible, even when all the berths are occupied, to allocate a fourth crane at one of the berths. This is not frequently required for timber ships, but is often used for vessels discharging cargoes of ore or scrap-iron. Between "A" and "C" Jetties is "B" Jetty, approximately 600-ft. in length. This is a stone jetty with a timber extension, but it is not equipped with cranes and is used by vessels discharging timber cargoes to quay. East of the entrance channel from the Central Dock is the sixth crane berth, equipped with two hydraulic cranes of 2-tons capacity. This quay is approximately 280-ft. in length, and is therefore "Tay Bridge" coaling staith with its two gravity spouts and one electric belt conveyor. The West side of the dock is occupied entirely by Messrs. Wm. Gray's dockyard. Here are three launching berths and No. 1 graving dock, which is 386-ft. in length and can accommodate vessels of 53-ft. beam.

No. 2 dock warehouse, a five-storeyed building of stone construction, 360-ft. by 95-ft., is fully equipped with railway lines, capstans, turn-tables and electric hoists. The ground floor is now almost exclusively used for the storage of sawn timber, but the upper floors are available for general merchandise. Prior to the war, this warehouse was extensively used by steamers discharging general cargo, but this trade has now ceased and the warehouse is now rarely used in this way. The stone quay to the East of the warehouse is equipped with a 17-ton hydraulic crane, but is not often used for loading or discharging steamers, although small quay cargoes of timber can be accommodated there as required. The crane is used for dealing with any exceptionally heavy lifts which may be required. Near the end of No. 2 warehouse, but not actually adjoining the dock, is No. 9 warehouse, a single-storey structure 150-ft. by 30-ft., specially adapted for the storage of timber.

Coal Dock

The Coal Dock, which was the first dock to be opened at West Hartlepool, has an area of $8\frac{1}{2}$ acres. As its name implies, it is devoted entirely to coal shipping. On the East side is a high-level staith, providing two coal shipping berths. Both berths are equipped with two gravity spouts, and that on the North end of the staith has, in addition, an electric belt conveyor. Originally, there was an additional berth on the West side of the dock, provided with a coaling hoist, but this has now been removed, as has also a small jetty which extended from the middle of the South side of the dock. The Canal Dock is largely used by smaller vessels taking cargoes of coal and coke, and provides a useful facility in times of pressure to relieve the main staiths in the Victoria Dock and Old Harbour.

The Hartlepools—continued



Trawlers at the Fish Quay, Hartlepool.

Swainson Dock

To the West of No. 2 warehouse is the channel which gives access to the Swainson and Timber Docks. The Swainson Dock, with an area of approximately 9 acres, is not now very extensively used, although a regular monthly steamer from Gothenburg discharges most of its cargo at No. 5 Shed, which is situated on the South side of the dock. Messrs. Gray's dockyard abuts on to the North side, where the Company's offices are situated. Here also are two launching slipways for smaller vessels than are built in the Central Yard or in the Jackson Dock berths, and also another graving dock, No. 2, 349-ft. in length, which can accommodate vessels up to 47-ft. in beam. No. 4 dock warehouse occupies the entire length of the East Quay. This is a similar building to No. 2 warehouse, being of stone and five storeys in height, but is slightly greater in area. Two of the three main bays of the ground floor and one bay of the first floor are occupied by the factory of the North of England Match Company, which was founded in 1933. A further portion of the ground floor is used also as a store by a firm of egg importers and merchants.

The remaining space is used for the storage of sugar, paper and other general goods.

Hart Dock

Messrs. Gray's premises extend along the whole of the Eastern side of the Timber or Hart Dock, which is entered from the West corner of the Swainson Dock. Like the Swainson Dock, the Timber Dock has no crane berths, and is not now used to any great extent, although small vessels occasionally discharge their cargoes to quay there. It was extensively used in the days of sailing vessels and is still useful as providing a space where small vessels, such as fishing craft, can be laid up if required.

Union Dock.
Discharging Scrap Iron and Steel by Grab at "C" Jetty.

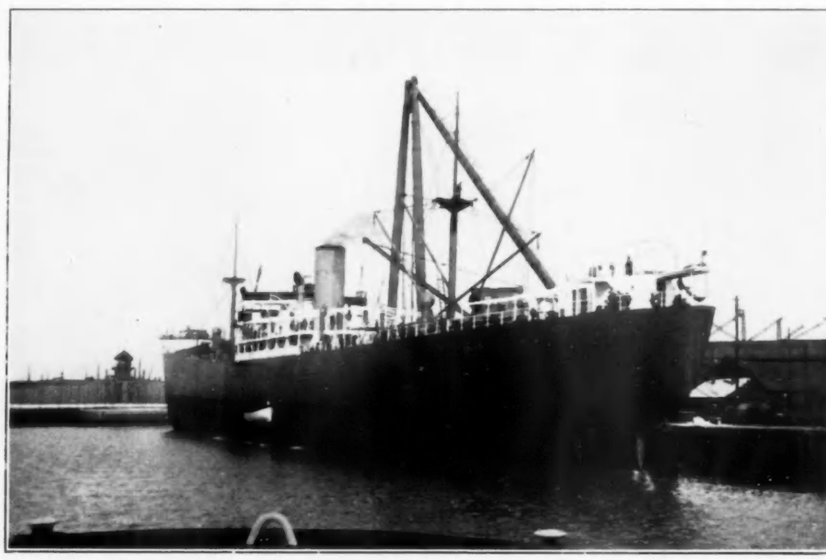
Timber Storage Facilities

As has been previously mentioned, the principal import at the Hartlepools is timber, and this being so, it has been necessary for a large area of ground adjoining the various docks and further afield to be set apart as storage ground for this commodity. Approximately 130 acres is available for this purpose, and has been equipped by the Railway Company with suitable siding accommodation. In addition, a considerable amount of space is utilised on the various dock quays on to which cargoes can be discharged direct.

It will have been noticed that the ground floors of practically all the dock warehouses are also adapted for the storage of sawn wood, which it is desired to keep under cover. Furthermore, many of the merchants have their own sheds for this purpose.

No description of the timber storage facilities would, of course, be complete without mention of the extensive timber ponds which, as will be seen from the illustrated Supplement adjoin the Central Dock. These ponds have a total area of approximately 30 acres and are largely used for imports of sleepers and sleeper blocks for the Railway Company, whose Creosote Works are connected by a channel which enables the timber to be floated direct from the pond to the works.

Special facilities are provided by the Railway Company for the haulage of traffic from the quays to the timber storage grounds and a large number of wagons, known as dock wagons are set aside and used exclusively for this purpose. It should be mentioned that all traffic discharged from ships by crane is



S.S. Haughton Hall, at 100 ton sheer legs, North Basin, after being fitted with engines by Messrs. Richardsons, Westgate & Co. No. 1 Swingbridge, spanning the entrance from Old Harbour in the background.

loaded into railway wagons. All the crane berths at the port are equipped for rail transport only.

Towage

The towage services, both for assisting vessels to and from sea and for any moves which are necessary within the port itself, are undertaken by the Railway Company, who maintain for the purpose a fleet of six powerful twin-screw tugs.

Pilotage

The pilotage services at the port are undertaken by an adequate body of qualified pilots under the supervision of the Hartlepool Pilotage Authority, who maintain a modern steam pilot cutter, which enables an efficient service to be given to all vessels entering and leaving the port.

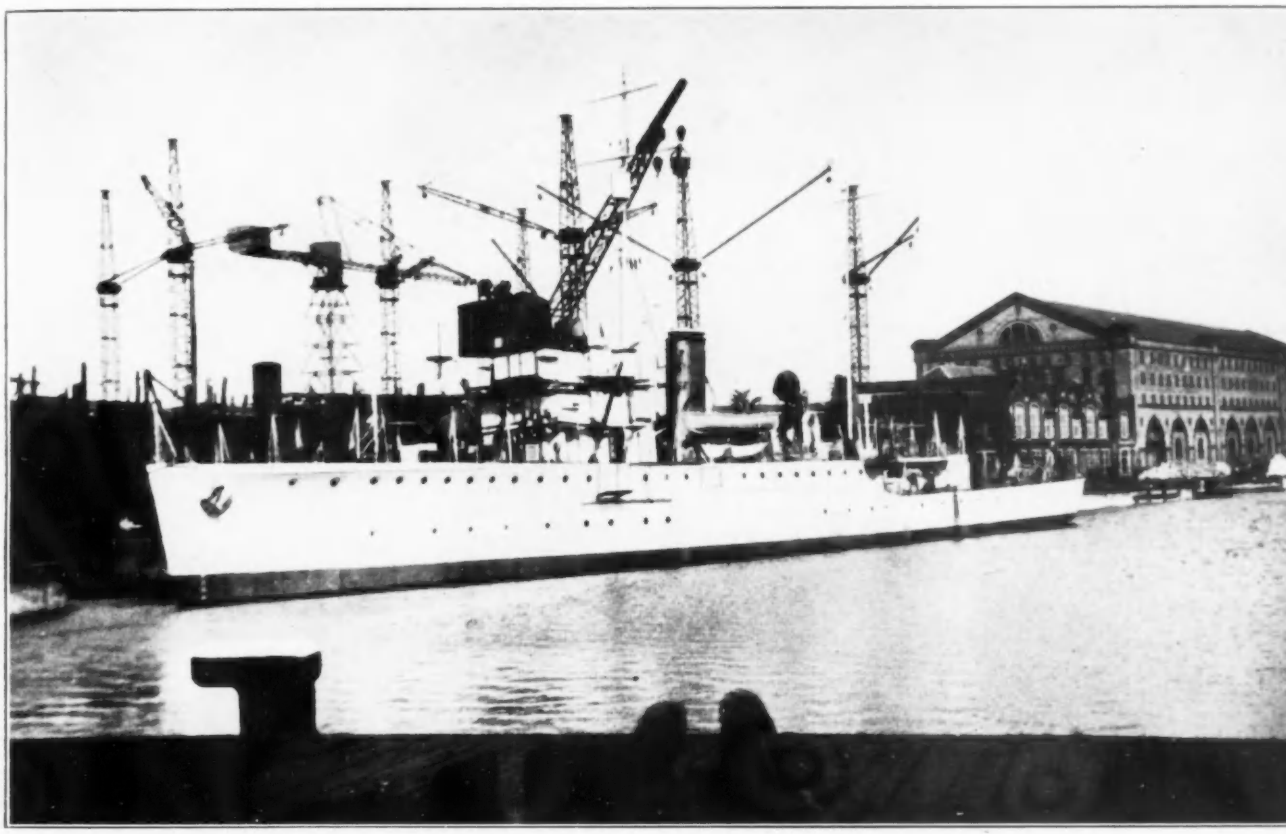
Signals

As has been mentioned previously, the only entrance to the docks now used is that at Hartlepool, and vessels for the West Hartlepool docks enter via the Old Harbour and North Basin. The channel into the Old Harbour is about half a mile in length, and is insufficiently wide to allow of more than one vessel navigating it safely at the same time, and signals are therefore necessary to regulate the passage of ships in and out.

For many years these signals were exhibited from a 75-ft. mast situated at the Hartlepool Dockhead, and took the form of the usual arrangement of black balls by day and green lights by night from four positions at the mast-head and upon a gantry fixed thereto. The signals must be visible for at least three-quarter's of a mile seaward over an arc of approximately half a mile in width, and three different indications are required. In order that the same indications might have the

The Hartlepools—continued

same meaning by day and by night, colour light signals have recently been introduced for use by day and in order to avoid conflict by night with existing red leading lights and other white lights on the line of vision the signals which are placed at the top of a 30-ft. mast display a green light, an amber light or no light, as the case may be. Four separate lamps are used, two for daylight and two for night use. To obtain the necessary penetration by day special lenses have been provided in conjunction with a 500-watt electric lamp for the green light and a 250-watt lamp for the amber light. The respective night aspects present no difficulty, and are obtained by 100-watt and 600-watt lamps for the green and amber lights respectively.



H.M.S. "Hazard" lying at the Dockyard, Swainson Dock. No. 2 Warehouse in background.

Similar colour light signals are provided on a separate mast for the guidance of vessels proceeding to sea, but in this case the same lamps which are used by night are adequate during daylight, owing to the much shorter distance for which they are required to be visible.

Principal Imports and Exports

Timber

It will be seen from the foregoing historical notes that the Hartlepools developed primarily as a coal exporting port, and in the early days import trade was not very seriously considered. Now, however, the import business ranks equally with coal shipment. This is due mainly to the development of the timber trade for which the port has become an important centre, and for which it has been specially equipped and laid out. Other important imports are, of course, regularly dealt with, but timber is by far the most considerable import.

Old records show that timber was first brought to the port during the early fifties of last century, and for many years the greater part of the import consisted of sawn wood. The reason for this was that the mines used stone and home-grown timber, and such mining timber as was imported came into the Tyne and the Wear. The sawn wood was used for ship and house building, and in this latter connection it must be remembered that West Hartlepool grew from a tiny village to a flourishing town (with a population of more than sixty thousand) in less than sixty years, so that the local consumption alone must have been very heavy.

By 1900 the pit-wood import had begun to exceed that of sawn wood, and this state of affairs has continued until the present time, the port having become an important centre for timber for the mining industry.

Records of the quantity of timber imported are available since 1852, and the following table gives the figures in loads for a number of years since that date. 1923 is included because in that year the record quantity was received. 1937 has seen a very great increase in imports over the last few seasons, and has not fallen very far short of the record year.

Year		Timber in Loads	Year		Timber in Loads
1852	...	531	1923	...	756,014
1860	...	74,297	1930	...	469,127
1870	...	243,843	1931	...	324,826
1900	...	573,849	1935	...	448,245
1913	...	576,950	1936	...	467,603
1919	...	381,518	1937	...	688,899

Ore

Next in importance to timber comes the import of iron ore for local blast furnaces. Ore from Spain was imported as long ago as 1861, and in 1913 the tonnage of foreign ores passing through the port exceeded half a million. In 1926 the local iron works were compelled to close owing to depression, and the import, of course, ceased, but it is pleasing to record that it has again been resumed, following a re-opening of the furnaces this year.

The importation of zinc ores from Australia and Newfoundland for local works to the extent of approximately 20,000 tons per annum has unfortunately been suspended, owing to the closing down of the spelter plant, but it is hoped that this suspension will only be a temporary one.

Miscellaneous

Among other imports dealt with are wood-pulp for paper making, scrap-iron and steel, tiles, chalk and clay.

Coal and Coke

The only considerable export from the Hartlepools is, of course, coal and coke, the shipment of which has always been the lifeblood of the port. It is recorded that in 1854 the tonnage of coal shipped had reached 1,700,000 tons. Approximately twice this tonnage represents a good year's shipment nowadays, the record export being that for 1929, when 3,447,676 tons were shipped. The traffic consists largely of steam and gas coals from the neighbouring South-East Durham coalfield and a large proportion of the tonnage goes coastwise to London, although a considerable quantity is shipped to Continental and more distant foreign ports. The following table shows the tonnage of coal exported for certain years since 1850, and indicates the steady increase which has taken place in the shipments. There have, of course, been occasional checks in this progress, as for instance in 1926, when the tonnage fell below the million mark for the first time since the records commenced, and in 1931/1932/1933 when the industrial depression was at its worse. The 1935 export just failed to reach the 1929 record, and this figure has been nearly approached by the 1937 shipments.

The Hartlepools—continued

Year		Coal and Coke Tons	Year		Coal and Coke Tons
1850	...	1,505,924	1926	...	843,530
1860	...	1,887,726	1929	...	3,447,676
1870	...	1,490,715	1930	...	3,251,444
1880	...	1,248,926	1931	...	3,188,662
1890	...	1,042,352	1932	...	3,167,141
1900	...	1,208,756	1933	...	3,187,119
1910	...	1,887,908	1934	...	3,315,250
1913	...	2,400,571	1935	...	3,435,802
1919	...	1,283,874	1936	...	3,143,075
1920	...	1,550,942	1937	...	3,355,905

Shipment is carried out from high-level staiths from which coal is run from hopper wagons either by means of gravity spouts or electric belt conveyors. The bulk of the trade is done in ships of up to two or three thousand tons capacity, but larger steamers carrying up to eight thousand tons are frequently loaded. All the coaling appliances are capable of dealing with 20-ton mineral wagons, which are extensively used for shipment purposes.

Local Industries

Shipbuilding and Repairing

No account of the Hartlepools docks would be complete without mention of the important shipbuilding industry which is carried on in the port. Actually shipbuilding work is now limited to one firm, that of Sir Wm. Gray & Co., Ltd. This firm has in the past held the record for the greatest tonnage launched in any one year on no less than six occasions, and although in common with other shipbuilding concerns it has suffered from the recent depression, its yards are again busy and launches have become a common feature of the life of the port. The firm is particularly noted for the building of high-class cargo vessels, and also undertakes a great deal of graving dock and repair work.

All vessels from the firm's two yards are launched into one or other of the docks themselves. As mentioned previously, most of these vessels are engined by the Central Marine Engine Works at their yard adjoining the North Basin.

In connection with shipbuilding, mention should be made of the engineering works of Messrs. Richardsons, Westgarth & Company, Limited, who are noted, not only for their marine engines but for other machinery. Another local firm which now concentrates almost exclusively on ship repair and dry-dock work is that of Irvines Shipbuilding & Drydock Company.

The Fishery Industry

Fishery can claim to be the Hartlepools' oldest industry, as it was undoubtedly carried on long before the modern development of the port began. Although still an important part of the port's activity, the tonnage landed has decreased considerably in the last decade.

Excellent facilities, however, exist for the supply of coal and ice to trawlers, which are accommodated at a commodious and well-protected quay completed in 1910. Curing establishments and a fish meal factory are also located in close proximity to the quay.

This article is intended briefly to give a description of the port of the Hartlepools and of its equipment and the trade it handles. It will have been noticed that no mention is made of the harbour works outside the docks. These are under the jurisdiction of the Hartlepool Port & Harbour Commission, a statutory body composed of representatives of the Board of Trade, the Corporations of Hartlepool and West Hartlepool the London and North Eastern Railway Company, and of the Shipowners and Traders using the port. The work of the Commission, which includes the dredging of the Channel and outer harbour and the maintenance of protective works, was the subject of an article in the March issue of the "Dock and Harbour Authority."

Proposed New Port in Peru

A contract has been entered into by the Government with the Frederick Snare Corporation of New York, Havana and Lima, for the construction of a new port at Matarani, Southern Peru, and the extension of the existing port works at Callao. The amount of the contract is 21,838,080 soles (almost £1,100,000).

Matarani, which is located about fifteen miles north of the Port of Mollendo, will replace Mollendo as the Pacific terminus of the Southern Railway of Peru, which now serves the Arequipa - Cuzco - Lake Titicaca region, and connects with La Paz, Bolivia, on the through rail route to Buenos Aires. Mollendo is located in an open roadstead, whereas Matarani is in a well-sheltered bay.

The sum of 15,721,920 soles (about £800,000) has been appropriated for the Matarani project, which will be completed in three years. Two breakwaters, 610 metres and 150 metres long (2,002-ft. and 492-ft.), will shelter the inner harbour, which will have a wharf 450 metres (1,476-ft.) long.

Four large, modern warehouses will be constructed on the wharf with Customs and other requisite buildings; 1,874,000 cubic metres (2,451,192 cubic yards) of rock will be excavated from the shore line for the breakwater and wharf filling. Steel cylinders filled with rock will be the main foundation of the wharf.

The programme for the extension of the Callao docks, on which 35,000,000 soles (approximately £1,750,000) has been spent in the last ten years, includes the building of a new 467 metre (1,532-ft.) bulkhead connecting the new docks with the old French docks, built more than half a century ago. An area of 173,000 square metres (206,908 square yards) along the present Callao waterfront will be reclaimed by filling in the land behind the new proposed bulkhead, which will be utilised for new streets and building sites along the waterfront.

This new extension requires an additional expenditure of 6,114,160 soles (approximately £300,000), and will be completed within three years. The entire undertaking will be financed by the Reserve Bank of Peru at a low rate of interest.

The foregoing items do not include the new and modern graving dock and naval arsenal at Callao now nearing completion, at a cost estimated to amount to £300,000. This graving dock will take the largest liners now engaged in the trade on this coast.

French Port Traffic during 1937

The following statement is extracted from a recent issue of the "Journal de la Marine Marchande."

During 1937, the improvement which was recorded in 1936 continued. The rise, which was slight as regards the number and net tonnage of vessels, is appreciable in the case of goods traffic, amounting to 4,215,308 tons (nearly 9 per cent.), as against a rise of 2,908,681 tons (6 per cent.) in 1936, as compared with 1935. There was also a noteworthy advance in the movement of passengers (plus 17½ per cent.), mainly due to the flow of visitors to the Paris Exhibition.

The following table shows the movement of traffic in 1937, as compared with that of 1936:—

1937	Inwards	Outwards	Total
Ships	86.348	86.289	172.637
Tonnage	72.911.846	72.776.436	145.688.282
Goods (tons)	40.634.075	12.065.366	52.699.441
Passengers	3.005.325	2.862.001	5.867.326
1936			
Ships	85.606	85.119	170.725
Tonnage	71.840.301	71.517.142	143.357.453
Goods (tons)	36.711.073	11.773.060	48.484.133
Passengers	2.524.689	2.455.028	4.979.717

The increase of 4,215,308 tons in goods is accounted for almost entirely by entries (plus 3,923,002), and is due particularly to imports of coal and oil, while clearances only showed an advance of 292,306 tons. It is to be noted, however, that the latter had fallen in 1936 by about 75,000 tons, as compared with 1935.

There was a considerable rise in the number of passengers, viz.: 887,609, or 17½ per cent., and it is interesting to note that the improvement related almost entirely to the services, including those of Corsica and North Africa, which carry touring traffic, whereas coastal traffic was practically unchanged.

Marseilles, including its annexes, remained last year at the head of French ports, from the point of view both of registered tonnage (32,110,586) and weight of goods handled (9,777,583 tons).

As regards goods traffic, Rouen was second (9,058.958 tons), followed by Havre (6,084,249 tons), whereas from the point of view of tonnage, Havre was second after Marseilles (23,124,258 tons) and Cherbourg third (14,822,874 tons).

The Breaking of Waves against Vertical Sea Walls

Researches of Monsieur J. LARRAS

By HERBERT CHATLEY, D.Sc. (Engineering), M.Inst.C.E.

A VERY important paper has been published by M. Larras (No. 26 in the "Annales des Ponts et Chaussees," 1937, pp. 643-680), dealing with the magnitude and pressure of breaking waves. His research has been made by model experiments carried out in conjunction with M. Delort, checked against actual observations of marine conditions and mathematical theory, including in the latter the vortex train theories of Bènard-Karman.

He confines the definition of "breaking" to the characteristic case of the violent liberation of energy in the form of rollers (Fig. 1) or volutes (Fig. 2) upon sloping shores or of "bundles" (gerbes) (Fig. 3) thrown against more abrupt obstacles.

His model consists of a steel tank, 25 metres long, 0.50 metres wide and 1.50 metres deep, with a glass window in one side 4 metres long, such as had already been used in his previous researches on reflected waves ("clapotis").

A swell generator, operated by a 3-h.p. electric motor, is at one end of the tank, and at the other end are the experimental surfaces, a vertical wall which can be varied in position and a slope that can be varied in angle and length.

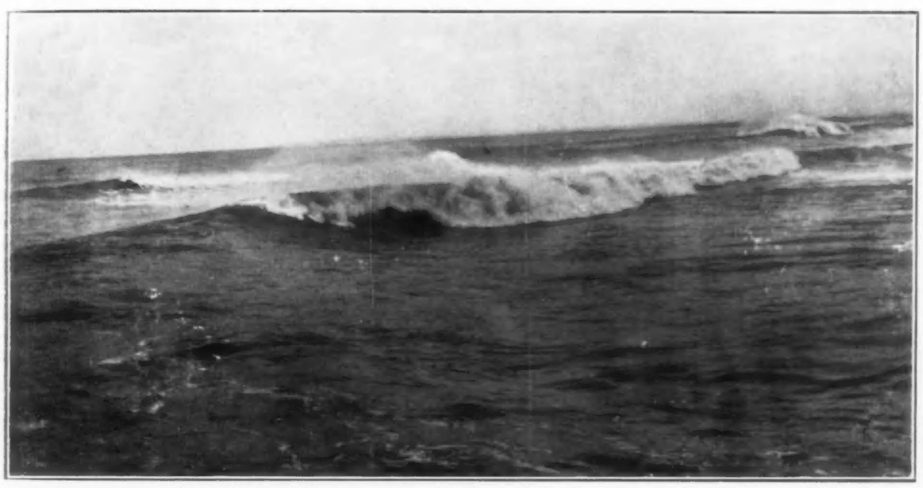


Fig 1. Wave breaking in rollers.

The generator produces waves with periods (2T) of 0.8 to 1.8 seconds, lengths (2L) from 1 metre to 3.30 metres, and range to length ratio (2h/2L) from 0.05 to 0.09.

The conclusions from the initial experiments were very definite:—

"When, for a given swell, one set up the vertical wall at various points of the terminal slope, the position of the wall for which the breakers become most violent coincides with the position of the rollers on the same slope in the absence of the vertical wall. In other words, the waves break against walls in the same depths as they do upon slopes, despite the mathematical theory of reflected waves which claims to distinguish between the two phenomena. Such a result would appear, moreover, evident *a priori* since 'breaking' carries the idea of complete destruction of energy, whereas the 'reflected wave' indicates contrariwise the conservation of energy, but it was considered important to bring this essential point into view at the outset of the new researches."

Theoretical analysis (of which full details are given in the appendices to the paper) led to the following results:—

(1) The classical formula

$$E_{\text{Kin}} = \tfrac{1}{2} \rho g h^2 L$$

which represents the kinetic energy of a circular swell of height 2h, wave length 2L, in water of density ρ and indefinite depth, also represents the kinetic energy of an elliptic swell of height 2h and wave length 2L in any water depth whatever, even very little.

It should be observed that in the metre-kilogramme-second system, ρ for sea water is 1,025 kilogrammes per cubic metre, and g is 9.81 metres per second per second. M. Larras gives the kinetic energy for his models as 50 to 100 watt-hours consumed per hour. One watt hour is 0.102 kilogramme-metres × 3,600 = 367.

(2) The crest of the breaking waves reaches an amplitude $z = +1.5h^1$ and the trough $-0.5h^1$, in relation to the still water level, where $2h^1$ indicates the height (range) of the breaking waves.

(3) The range $2h^1$ and the wave length $2L^1$ of the breaking wave and the breaking depth H^1 depend only on the range 2h and the wave length 2L of the free swell in indefinite depth, as a function of the ratio 2h/2L, in accordance with the following table:—

Free Swell	Breaking Wave				
2h/2L	$2h^1/2h$	$2L^1/2L$	H^1/h	$2h^1/2L^1$	H^1/h^1
0.01	2.02	0.24	2.06	0.08	1.02
0.07	1.35	0.55	1.54	0.17	1.12
0.13	1.20	0.70	1.48	0.22	1.24

Experiments with the model checked the values of the kinetic energy. Both sea observation and model experiments checked the conclusion that the height of the crest of a breaker was three-quarters of the range, or double amplitude, above and one quarter below the still water level.

On the other hand, the theoretical conclusions do not apply to large storm waves. Thus the ratio H^1/h^1 (breaking depth to half breaking wave range), which defines the most interesting feature of wave breaking, is always well above the computed value (1.0 to 1.2), being known to be often more than 2 and sometimes as high as 5.3.

It was therefore concluded that the classical wave theory cannot be simply extrapolated to the breaking state, and that either

1. The slope entirely changes the wave laws which are known to be valid for perfectly horizontal bottom surfaces, *or*

2. The waves do *not* break when the orbital speed U^1 at the surface is equal to the speed of wave propagation V^1, *or*

3. Wave breaking only occurs after a preparatory period of non-conservation, i.e., internal destruction of kinetic energy.

Cinematographs of waves seemed to show no important difference between U^1 and V^1, although Gaillard has cautiously admitted the possibility of a slight difference, but this seemed inadequate.

Analysis, using the Karman vortex theory, does not annul this disagreement if the mechanical energy of the waves is approximately maintained and the vortical energy remains small up to the moment of breaking. It seems, then, that there must exist, immediately before the violent turbulent phase of breaking, properly so called, a rapidly unstable state of strong vortical agitation corresponding to important loss of mechanical energy without great change of the external profile of the wave.

An endeavour to test this hypothesis with the model was made. First of all, it was found with what slope the experimental results corresponded to those of the classical wave theory (H^1/h^1 about unity), and it appeared that this was the case when the slope was 20 per cent. (11°20′). The hypothesis of internal vortical disturbance before breaking should then be easy to verify:

(1) If the slope were lengthened by reducing the angle, the period of preliminary disturbance should be correspondingly extended, so exaggerating the deviation between the classical theory and the facts. This actually appeared to be the case, a flattening of the slope down to five per cent. increasing the value of H^1/h^1 to 3.72.

(2) If the surface of the slope were covered with a rough mat, the antecedent turbulence should be increased and the deviation from classical theory should be enhanced. This also agreed with the facts, the value of H^1/h^1 for the 20 per cent. slope being raised to about 1.50.

The kinetic energy of the breaking wave (first roller) was found to bear a ratio to that of the generating swell which is about unity when H^1/h^1 is about unity and diminishes as H^1/h^1 increases.

The Breaking of Waves—*continued*

M. Larras takes care to observe that the experiments only refer to the first roller, that the waves are shorter than the length of the sloping shore, that the bottom was not mobile, and that no wind effects were considered. Nevertheless, observations on the shore at Algiers indicated the same parallelism between the H^1/h^1 ratio and the wave energy loss ratio and the same limits for the ratio H^1/h^1 (1 to 4, with an exceptional case of 4.88, corresponding to 83 per cent. loss of energy before breaking).

So he deduces that phenomena on the natural scale are approximately the same as in his experiments, and hence concludes as follows:—

(1) The probability of a wave breaking against a vertical wall ought not to be excluded *a priori* when the depth at the foot of the wall is less than $5h^1$ below low tide, where $2h^1$ is the maximum height of exceptional waves.

Fig. 2. Wave breaking in Volutes.

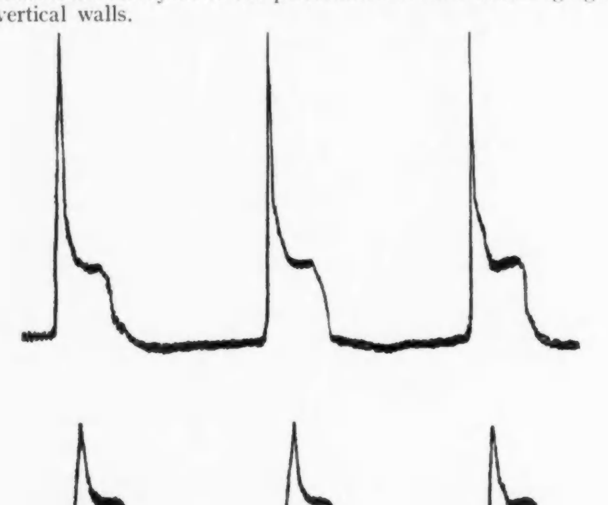
(2) Nevertheless, one can construct vertical walls with depths somewhat less than $5h^1$ below low tide without the certainty that waves will break when they attain a range $2h^1$. Such boldness will be all the more permissible if the foreshore is smooth.

(3) It would, however, show imprudent boldness to erect vertical walls with depths alongside of the order of $3h^1$, as some have proposed, especially if there is no exact knowledge of the maximum range of exceptional waves.

(4) One should be extremely cautious in the use of rubble aprons for the protection of the foreshore in front of a vertical wall, however otherwise advantageous, since these diminish the depth of water and increase bottom roughness, thus doubly encouraging the breaking waves, especially individual ones of great range.

(5) Two waves of similar external appearance may have very different internal structure, so that it is not justifiable to assume that the orbital movements are simple functions of the external dimensions of the wave and the depth of water.

(6) There still remain enormous advances to be made in mathematical physics before arriving at useful practical conclusions from theory as to the possibilities of wave breaking against vertical walls.



Wave Pressures on Walls.
Above: Wave Breaks at once.
Below: Wave Breaks a little in front of Wall.

Wave Breaking Pressures

The paper continues to describe tank observations of wave-breaking pressures by means of a piezometer, amplifier and electric recorder. The vertical walls were placed at the depth where the most violent breaking occurred and on various slopes from 5 to 10 per cent. Pressure readings were taken at various levels on the vertical walls. It was found that there was a violent "smack" (gifle) followed by a rather steady pressure (bourrage), the whole effect, in the model, lasting about half a second.

The "smack" in the experiments was always very brief in relation to the wave period. Its violence diminished considerably when the waves did not break quite vertically under the wall. The transient over-pressure shows rather uniformly over a large area near to the still water level, and can attain a head value of 5 or 6 times the half range of the breaking wave for small values of H^1/h^1.*

The steady after pressure, on the other hand, endured for a considerable fraction of the wave period, did not diminish much when the waves broke somewhat away from the face of the wall, and was greater near the base of the wall. The after pressure also increased with the period (and therefore the length) of the waves, but did not appear to depend primarily on the range $2h^1$ of the breaking wave, on the depth H^1, on the slope or on the roughness of the bed. This result appears rather surprising, but it should be observed that the submerged height of the walls in the experiments depended directly on the height $2h^1$ of the breaking waves, and the independence of the pressure per unit area in regard to that height $2h^1$ therefore in no way contradicts the elementary fact that the *total* thrust of the breaking waves on the wall depends directly on their height $2h^1$. Finally, one ought also to be cautious in generalizing, in a matter so important, from observations relating to only narrow variations of $2h^1$, $2T$ and H^1/h^1.

The next step was to ascertain the effect of reducing the height of the vertical wall down to mean water level. The "smack" then disappeared and the waves more resembled a "reflected wave" rather than a breaker. The after pressure was reduced to about half and for the long waves, which are always the most dangerous, these pressures were even less than indicated by calculation for a standing reflected wave of the same amplitude. The unit after pressures of the breakers proved to be relatively independent of the under structure of the walls, the increase of pressure being only about ten per cent. from an absolutely vertical wall to a wall with the most bulky substructure.

No comparison of these observations with natural scale results was feasible, on account of the insufficiency of wave descriptions and the large inertia of the usual wave dynamometers which do not discriminate between the smack and the after pressure.

M. Larras' practical conclusions as to wave pressure are:—

(1) A vertical wall is not necessarily in danger when the waves surmount it, and it is better to use the weight of the upper masonry in thick submersible platforms rather than in high walls which are difficult for the waves to surmount. It would then generally be better, once the "paper weight" effect of the platform has been established, to avoid as much as possible the construction of a parapet which increases the external surface of the wall and also the unit pressures on its face more than it increases the mass of the masonry.

(2) The fact that a vertical wall low on the water behaves well during a tempest does not prove that another heavier but higher work will behave better, or even as well, during an analogous tempest approaching at the same angle.

(3) Lacking suitable registering dynamometers, one should use maximum reading dynamometers of very small inertia for the study of breaker "smacks" and maximum reading dynamometers lightly damped for the study of after pressures.

The paper closes with a reference to the need for further studies of the oscillations of the walls, the distribution of pressure in and under the masonry, and of turbulence and cavitation in the waves themselves. There are a bibliography of twenty items and three mathematical appendices on

* The sharp noise made by this "smack" is a matter of common observation. M. Pétry discusses the question of air compressed in the wave in "Comptes Rendus," 205, pp. 437-440, 483-484, August 30 and September 13, 1937.—H.C.

The Breaking of Waves—*continued*

wave theory (Internal kinetic energy of waves, breaking of non-turbulent waves; breaking of turbulent waves).

One interesting indication from the third appendix is that the speed of propagation of a vortex group tends to a form

$$V = \sqrt{gH^1/2} \text{ instead of } \sqrt{gH^1}$$

As the author remarks, "Such a result is not astonishing since there is not, properly speaking, a speed of propagation of a wave of translation when the latter is not solitary, and, since each of its elements possesses its own particular speed of translation, there results disagregation (breaking) at very short notice."

This paper appears to be the most important contribution to the knowledge of wave action that has been made for several years, and it is to be hoped that M. Larras will carry on with the researches which have proved so informative.

Fig. 3. Wave breaking in "gerbes" against an abrupt obstacle.

New Wagon Cradle for Coaling Cranes

(CONTRIBUTED)

The following description has been received of a recent improvement in the method of handling of coal wagons at the quayside. The contrivance is the subject of a patent by the inventor, Mr. Frank Courtney of the Traffic Superintendent's Department, Clyde Navigation Trust.

In coal cranes at present, where a wagon of coal or other material, is required to be loaded into a ship's hold, the wagon is run on to a cage or cradle, which comprises a soleplate fitted with sections of rails. The soleplate is connected at its sides by chains or cable slings to an overhead crossbeam, which in turn is connected to the lifting pulley block of the crane by means of a swivel joint, so as to permit the cage and contained wagon to be slewed into the desired tipping position, while suspended over a ship's hold or other receptacle. This slewing of the cage and contained wagon is meantime done from the ground by manual labour, hauling a length of rope attached to an end of the cage.

For tipping the cage and contained wagon, chains or cables are provided at that end of the cage which is to be raised, these chains or cables being connected to separate winding mechanism in the power-house of the crane.

The main feature of the invention is the automatic slewing device provided for slewing the cage, instead of by manual labour, and comprises an electric motor carried on the crossbeam of the cage, and connected through gearing to the lifting pulley block of the crane. The slewing of the cage is controlled from the power-house of the crane, and the reduction gear is so arranged as to slew the cage slowly, so that appreciable rotational reaction is not transmitted to the depending lifting pulley block of the crane.

The tipping process is also effected by means of an electric motor carried on the crossbeam of the cage, and is provided with a winding drum for cables which are connected to that end of the cage which has to be raised.

The motors may be connected to a source of electric supply by flexible conductors, and can be conveniently controlled by the operator in the power-house of the crane.

From the foregoing it will be observed that the slewing apparatus referred to is provided to slew the cage or cradle and contained wagon into a desired position over a ship's hold while suspended on the hoisting cables of a crane. The operator may slew the cage and contained wagon, irrespective of any move the crane may be making.

The Maritime Services Board of New South Wales

Excerpts from the Second Report of the Board for the Year ended 30th June, 1937

Port of Sydney

Financial.—The accounts for the year ended 30th June, 1937, show a net surplus of £255,427 3s. 2d., which was an improvement of £64,043 9s. 4d., as compared with the previous year, when the surplus was £191,383 13s. 10d.

It is necessary to qualify the foregoing figures by directing attention to the fact that provision has not been made for the depreciation of the Board's wasting assets amounting to approximately £5,000,000 at the Port of Sydney.

Shipping.—The volume of shipping which entered the Port of Sydney during the year, namely, 19,151,394 tons (gross) eclipsed all previous records, and exceeded the figure of the previous (record) year by 1,019,773 tons. The number of vessels making up the aggregate tonnage was 7,295, as compared with 6,985 during the previous year, an increase of 310.

Oversea Shipping.—The number of vessels engaged in the oversea trade which entered during the year showed a decline of 39 (from 1,441 to 1,402). The gross tonnage was, however, greater at 11,277,610, as compared with 11,143,685 tons, an increase of 133,925 tons, or 1.2 per cent., and reflected the larger type of vessel now employed in the oversea trade.

Trade.—The total import and export trade of the port during the year was 7,481,102 tons, and constituted a record. The increase as compared with the previous financial year (record) was 328,949 tons, or approximately 5 per cent. The volume of imports amounted to 4,854,473 tons, as compared with 4,517,512 tons for the previous year, an increase of 336,961 tons; the exports, however, declined slightly from 2,635,241 tons to 2,627,229, or by 8,012 tons (.3 per cent.).

Wool.—The importance of the wool export trade of the Port of Sydney will be realised when it is stated that of the total value of all exports for the year, amounting to £55,001,618, wool represented £27,085,738, or 49 per cent.

Wheat.—The total quantity of wheat shipped from the Port during the year was 551,199 tons, as compared with 624,998 tons for the previous financial year, a decrease of 73,799 tons.

Flying Boat Base.—Following on the Agreement between the British and Commonwealth Governments to inaugurate an air mail service by means of flying boats between the United Kingdom and Australia, attention was directed to the selection of suitable sites for bases along the route. After protracted negotiations, the Federal Government decided to establish the Sydney base at Rose Bay in the Port of Sydney.

The Board has not yet been consulted with regard to the arrangements governing the arrival and departure of the flying boats. Before operations are commenced, however, a conference will be arranged between the authorities concerned as to the harbour waters to be used for alighting and taking-off purposes, with special reference to the interests of shipping lanes, restrictions to be imposed on pleasure craft, and other matters. It will be essential for the port authority to safeguard the interests of shipping generally, especially in the matter of a warning system in connection with the impending approach or departure of the flying boats.

Hydrographic Work.—The work of making a comprehensive hydrographic survey of the whole of the port was completed during the year.

The Cargo-Handling Equipment of Ports*

By M. PELTIER, Ingénieur des Ponts et Chaussées
(Director of Technical Services to the Chamber of Commerce, Marseilles)

I. General

THE equipment ("outillage") of ports, in the widest sense of the word, comprises the whole of the means placed at the disposal of shipping, goods and passengers, for the convenient handling of ships and the transit of goods and passengers. In other words, if a port consists essentially of a shelter, it is the equipment which enables this shelter to be used to the best advantage. It is to bring out these two complementary functions that a port is often defined by saying that it is "well sheltered and well equipped."

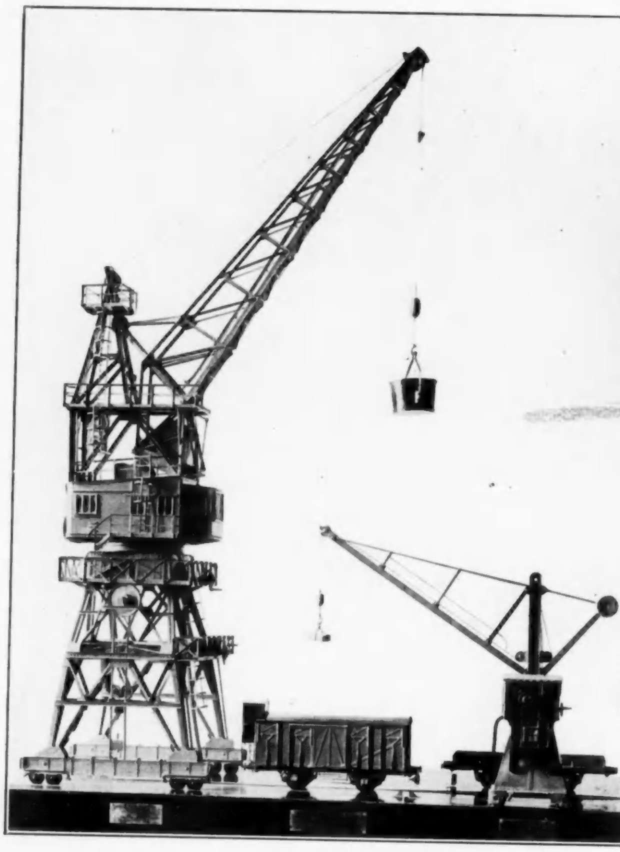


Fig. 1. Photograph of two models to the same scale, one of a Hydraulic Crane (1886) and the other of an Electric Crane (1936). From the Museum of the Marseilles Chamber of Commerce.

In a narrower sense, and this is the meaning usually attached to the word in administrative and practical terminology, the term "equipment" denotes the works above quay-level whose construction and operation are undertaken by Chambers of Commerce, by autonomous Port Trusts or by private companies; such installations, including cargo-handling machinery, goods sheds, landing stages and maritime passenger stations.

Even in this limited sense, the subject before us remains a very large one; so we will not only keep within the scope of this restricted meaning of equipment, but will confine ourselves to mention of the progress made in recent years and the leading ideas appearing to arise from the latest achievements in this line.

II. Quay Cranes for General Cargo.

The leading features of quay cranes for general cargo, which in most ports—at least in Europe—constitute the principal element of equipment, have developed considerably since 1918.

First, in regard to *capacity*, there may be noted a growing tendency to give up capacities of less than 3 tons. In many ports uniformity has been established by placing on general cargo quays none but 3-ton cranes. In other ports on the contrary and to an increasing extent, the policy is followed of placing on the same quay at the same time both 3-ton cranes and double-rated cranes of 3-5-ton capacity in a proportion of a third or a quarter of the total number. It is true that such cranes have to work, for most of their time, at a third or a quarter of their maximum power; but the small additional first cost involved in the increase of crane capacity is largely counter-balanced by appreciable economies in operation realised by users. They are thus in most cases spared either the always heavy cost of employing floating cranes or the delicate operation of employing two cranes working together.

The *dimensions* of cranes have developed to keep pace with ship-building and, whereas in 1914 cranes had a maximum outreach of the order of 14 metres, it is not unusual now for the cranes serving large liners to have an outreach or radius of 25 to 30 metres from pivot (corresponding to an effective outreach of 20 to 25 metres from quay face) and a height of 30 metres under the hook or 40 to 50 metres total.

These considerable increases of dimension have given rise to very difficult problems regarding the stability of such large machines and have led to progressive widening of gauge of crane portals and semi-portals. It even seems that, for large cranes to serve modern liners, it is desirable to have quays wide enough for the openings of portals and semi-portals to be at least 9 metres in gauge, this width allowing, moreover, for the passage of two running lines. Likewise one cannot too strongly urge the necessity of keeping the quay-side crane-rail far enough back from the cope line. The constantly increasing height of ships' superstructures, the adoption of overhanging bridges and gangways, the projection of lifeboats beyond the plane of the quay wall really involve grave risks of accident to the cranes at the moment of a ship's berthing or preparation. These risks are especially great in bad weather for then the ship may come in or go out obliquely to the quay and run the risk of bringing its bows or superstructures into contact with the quayside cranes. It is therefore considered that, at quays intended for large vessels, especially liners, it is prudent to increase to 3 metres at least the distance of the outer crane rail behind the cope line. It is true that this entails, in order to maintain the same effective outreach, an increase in the radius; but the increase in safety is well worth the consequent small increase in cost.

Besides the increase in size and capacity of cranes, the post-war period has been marked by the more and more general adoption of *level-luffing cranes*, in which the crane jib is luffed to alter its radius of rotation while the suspended load is kept at the same level. From the first the ingenuity of makers has been given free rein and very numerous systems have been tried. It now seems as if a period of stability has been reached. In fact nearly all luffing cranes now fall within two descriptions:—

(i) One with straight jib jointed at its base, with top sheave describing a circular arc, and

(ii) The other jointed, with rigid members, with top sheave moving nearly horizontally.

Both systems have their advantages and their drawbacks, but it may be said that they are now virtually standardised and that manufacturers can meet the particular needs of their clients in respect of variable outreach by adopting one type or the other.

These general data regarding the characteristics of cranes seem to require for their completion some indication of the *number* of machines to provide per ship's berth. We will, in this connection, refrain from giving figures applicable in every port or even in different parts of the same port. Determination of the crane density appropriate to a particular quay is in fact above all a local question.

It is evident that one would not equip on the same scale a short quay and a long one, the latter being able to render good service even with a limited number of appliances, firstly, because of the lesser likelihood of all its berths being occupied at one time and secondly, because of the feasibility of moving the cranes where wanted, etc. It is therefore enough to say that the density of cargo cranes (i.e., their number in relation to quay length) is very variable from one port to another and even from one part to another of the same port. Among the best equipped quays at the present time may be cited one of 290 metres (950-ft.) in length, with 22 cargo-handling appliances, that is an average of one to every 13 metres (43-ft.) of quay. This result is only achieved, however, by employing not only cranes of ordinary type, but also "double" and "triple" cranes, and the characteristics of these call for notice.

"Double" cranes include, firstly, a slewing crane on a semi-portal frame of ordinary type. In addition the frame carries a horizontal beam, at right angles with the quay front, on which runs an electric travelling crab. When not in use this beam is housed within the frame and does not project in advance of the

* A Paper read before the Seaport Congress, Paris, November, 1937.

Cargo-Handling Equipment at Ports—continued

Fig. 2. Type of recent Electrical Crane with variable loaded outreach—capacity 3 tons; track 9 metres; maximum outreach from quay 14 metres; height from quay to underside of block 25 metres.

cope line. In the working position the beam is projected out over the ship, so that the crab running along it comes over the hatch and fulfils its purpose. It is thus possible to work with two "hands" in the same hatch without taking up more quay-space than when working with one "hand" by an ordinary crane single-handed.

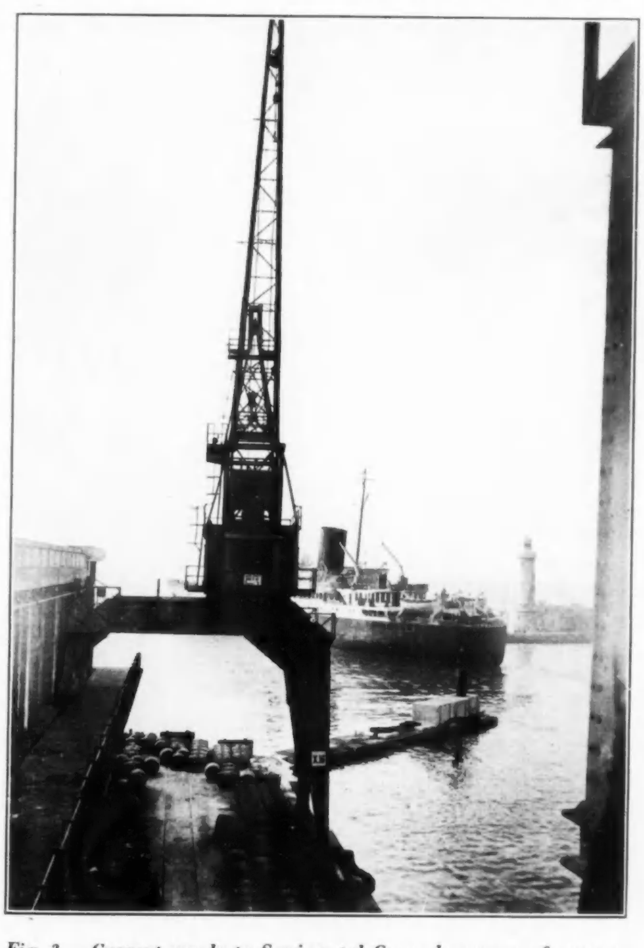


Fig. 3. Current supply to Semi-portal Crane by means of contact rails at shed platform level left side of photograph).

Other "double" cranes comprise, on the same portal or semi-portal, two semi-rotary, cranes, of which obviously each can only make a half turn

Lastly, there are "triple" cranes comprising one rotating crane of usual type and two travelling crabs carried in a manner similar to the single ones already described.

Examination of the operating conditions of this very advanced installation demonstrates that by well-considered arrangement it is possible to multiply working facilities without unduly encumbering the quays by crane portals or semi-portals.

III. Transporters for Handling Heavy Material

The handling of heavy material in bulk is increasingly dealt with by large transporters with lifting jib and travelling crab commanding broad stacking grounds. The capacity of such machines has been continuously increasing and it is not exceptional now to find them of 15-ton capacity, whenever the dimensions of ships allow it.

While the dimensions and capacity of transporters have thus been on the increase, it has been found necessary, in consequence of numerous accidents, to improve the methods of braking and of anchoring the transporters to their tracks. The general tendency now is to adopt safety devices applied automatically (by means of vanes or wind wheels) and coming into action whenever the velocity of the wind exceeds a dangerous value, whatever may be the position of the gantry on its track.

In order to increase the area served by a transporter, when it is working in a given hold of a ship, without having to move the ship, there has been recourse in some cases to transporters capable of slewing themselves in relation to their tracks. There seems, however, to be a growing practice of giving up that arrangement, which entails certain difficulties of construction and is a source of weakness in such transporters. It is found preferable to employ travelling bogies having a rotating portion with a jib whose outreach may be several metres long, so disposed that without moving the gantry one can command an area whose width is double the radius of the rotating jib on the traveller.

We also draw attention to important improvements effected in two-drum winches in the direction of increasing the safety and reducing the fatigue of the driver. Excellent results have been obtained, especially with double-geared winches with two motors, which enable all movements to be operated with the greatest flexibility and safety.

Cargo-Handling Equipment at Ports—continued

Lastly, even for high-powered machines, there may be remarked a tendency to increase in speed and especially in acceleration of the several motions, thanks to which the output is appreciably increased. It is not unusual, for example, for the travelling motion of 15-ton winch carriages to reach a speed of 3 metres per second with acceleration in less than 5 seconds.

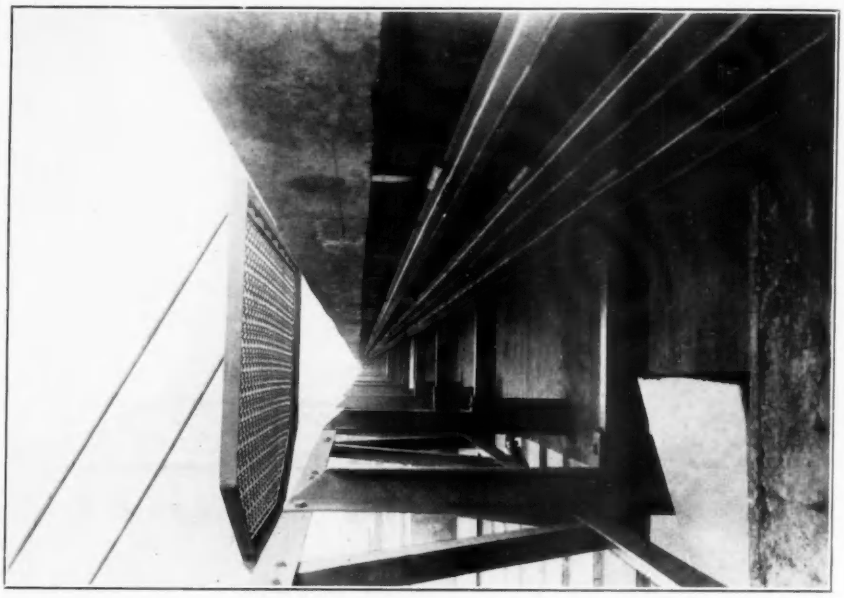


Fig. 4. View from under side of contact rails (T irons with copper "mushrooms") of the Crane in Fig. 3.

IV. Some Points in Construction of Modern Handling Equipment

In addition to the general indications already given, it seems useful to give some particulars of the more recent innovations in the matter of construction of cargo-handling appliances.

(a) Framing

There is a commencement, especially outside of France, in the construction of cranes with all-welded frames. The adoption of welding permits of reduction in weight, improvement in appearance and economy in maintenance and painting. Welding can equally well be applied to the strengthening of existing machines. It has, for example, been employed with success in strengthening the framework of large gantries, to enable them to carry more powerful travellers than those for which they were originally designed.

In another direction, there has been an endeavour to lighten the framing of cranes by reducing to a minimum the surfaces exposed to wind, by the omission of motor and machinery cabins. It is then evidently necessary to use enclosed motors and combined motor-winches totally encased excepting the drums. The adoption of such arrangements, however, which entail certain difficulties of maintenance, does not appear desirable except for machines whose stability can otherwise hardly be assured, by reason of local circumstances, especially narrowness of track.

With regard to gearing for the variation of outreach there may be observed the almost universal abandonment of rope systems—or even systems employing rope control—and the adoption of systems comprising pinions engaging in toothed or grooved sectors.

(b) Electric Motors and Machinery

Lifting appliances in general have obviously benefited by the great advances made during the past 25 years in electrical work. One may specially note in this respect the endeavours made to obtain hoisting motors having a continuous range of speeds, in order that speed may increase with decrease of load to be lifted. This effect has been achieved notably, with alternating current by the employment of series-wound motors. For example, here are some results obtained with a motor of this type:—

Weight Lifted	Revs. p. min.	Ft. p. sec.
Empty Hook	1,450	8
3 Tons	900	5
5 Tons	625	3·5

Of course, such motors are dearer in first cost than those of ordinary type, but this new method obviates the need for speed-changing gear, mechanical or otherwise, under the driver's control, and mistakes which are often costly.

The employment of cranes of very large radius has led manufacturers to adopt means of varying the angular slewing speed of cranes in inverse proportion to their variable radius. Experience has shown that it is important, from the cargo-handling point of view, for the linear speed of the load not to exceed a certain limit. It is therefore necessary to ensure that this limit of linear speed shall remain practically constant whatever the radius may be. This result is obtained by causing the angular speed to decrease as the radius increases. If driving motors are on alternating current, this can be effected by employing either single-phase Deri motors or shunt-wound double-brush motors, the speed adjustment of which is obtained by disengaging the brushes, the disengagement being controlled by the crane radius.

In regard to switch-gear, the tendency is towards the use of totally enclosed instruments without visible switchboards.

(c) Power Supply

We need only make a passing remark upon the controversy that was carried on between the advocates of direct and alternating current respectively, for A.C. installations have now generally established themselves, both in France and elsewhere.

We will confine ourselves to suggesting the desirability of adopting, whenever possible, the method of service by overhead trolleys, rather than by plug-boxes. The latter, besides heavy upkeep, make the movement of cranes expensive. Also the Flexible connecting cables require frequent replacement, especially after accidental damage. Supply by overhead trolleys, on the contrary, has none of these drawbacks. It is especially easy to apply to semi-portal cranes, for which the live conductors can be carried on the transit shed.

For large gantry cranes on open dumps, underground conduits are successfully used. Whether for these or for overhead trolleys it is advantageous to employ copper "mushroom" conductor rails, with their quality of rigidity, which reduces to a minimum the space required for the contact system.

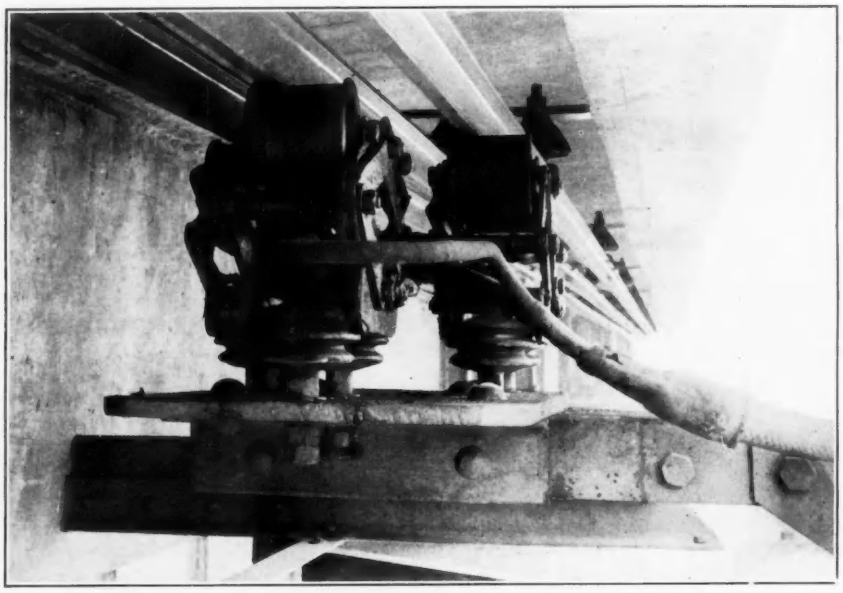


Fig. 5. Enlarged view of the pantograph of the Crane in Fig. 3.

V. Secondary Handling Machinery

While quay cranes and transporters for heavy cargo form the essential element in the handling equipment of ports, such machines do not cover the whole field. With regard to miscellaneous cargo especially, it is necessary, in order to handle it cheaply, to have available machines for transport and stacking on open dump or in covered shed. In this connection it would be difficult to exaggerate the very great utility of electric trucks and trailers, called "ants," for collecting from and for loading lorries or wagons; also locomotive cranes on caterpillar tracks, etc. These machines, generally speaking, are not expensive and, taking into account the variable nature of individual requirement,

(continued on page 211).

Notes of the Month

Bombay Port Trust.

In view of the greatly increased hours of duty devolving on the Dock Masters Establishment following the introduction of the docking and undocking of vessels by night, the Bombay Port Trust have created the additional posts of Dock Master and Berthing Master.

St. Augustine Harbour Improvements.

A scheme for the improvement of the harbour of St. Augustine, Florida, U.S.A., at a cost of approximately $275,000 has been approved. An entrance channel is to be constructed, 200-ft. wide and 27-ft. deep, from the Atlantic Ocean through North Point to Deep Water in Tolomato River, opposite the mouth of the Matanzas River.

New Ship for the Union-Castle Line.

The largest motorship of the Union-Castle Line, the "Capetown Castle" of 27,000 tons, built by Messrs. Harland and Wolff, Ltd., at Belfast, recently sailed from Southampton on her maiden voyage to South Africa. The "Capetown Castle" is 734-ft. in length and 82-ft. in breadth, and is the largest ship launched from a British shipyard since the "Queen Mary."

Wear Dock to be Leased.

The River Wear Commissioners recently approved a scheme by which the lease of the Commissioners' No. 1 graving dock will be granted to Messrs. T. W. Greenwell & Co., Ltd., ship-repairers, who will enlarge the dock and use it for extension of their business. The agreement to be entered into provides for the promotion of a Parliamentary Bill to give the Commissioners authority to lease the dock.

Improvements at Dover Harbour.

The Dover Harbour Board recently invited tenders for the leasing of land adjoining their Wellington Dock, and for the construction of a dry-dock at an estimated cost of £500,000. Accommodation at this, the western section of the port, comprises the 12-acre Wellington Dock, and the 6-acre Granville Dock, opening into a basin connected with the outer Commercial Harbour. The scheme is stated to be for a dry-dock to accommodate vessels up to 6,000 tons, with a maximum draft of 22-ft. Financial assistance is to be sought from the Dover Corporation and the Ministry of Transport.

Port of Beira Improvements.

Work has commenced on the construction of an additional deep-water berth at the Port of Beira. The new berth will be an extension to the existing wharf, where at present, there is sufficient accommodation to allow three ocean-going vessels to berth simultaneously. Two sheds are to be built alongside the wharf, in order to facilitate the handling of cargo. Messrs. Rhodesia Railways, Ltd., have already erected two further sheds for the accommodation of cargo for export, and it is hoped these additional facilities will alleviate the congestion which has prevailed hitherto.

New Tug Boats for Grimsby Docks.

Early in April, there was launched at the yard of Messrs. Richard Dunston, Ltd., at Thorne, near Doncaster, the first of two interesting steam tugs that are being built for the London and North Eastern Railway for towage work in their Fish Docks at Grimsby. The two vessels are being built to the same plans, but one of them is to be fitted with the Kort system of shipping propulsion. The work of both tugs under identical conditions at Grimsby Docks will be carefully recorded, and it is expected that some very valuable data may be obtained in this manner as to the value of the Kort propulsion nozzle, which is a tubular arrangement built around the propeller, giving greatly increased power of propulsion without increasing the engine's horse-power.

Dock Improvements at Swansea.

The Great Western Railway Company have invited tenders for the reconstruction of the "D" transit shed at the King's Dock, a large part of which was damaged by fire last year. The Company propose at the same time to effect improvements wherever possible, in order to facilitate the loading and unloading of vessels. Also, following the filling-in of the abandoned North dock, permission is to be sought to provide alternative means of supplying feed water to the North dock half tide basin, which is still in service for the importation of grain, the export of flour and other purposes. In order to carry out this improvement, it is proposed to construct a culvert under the River Tawe, between the Prince of Wales Dock and the basin, and to close the northern entrance to the basin from the river by the construction of a dam. The feed water will be siphoned from the main docks to the basin through this culvert.

Portsmouth Dockyard Extension.

The Admiralty have notified the Portsmouth Corporation that it is proposed to extend the dockyard over an area now occupied by four streets in the vicinity of the Marlborough Gate at Portsea. Also, to cope with the increasing requirements of the Fleet, the dockyard electricity station is to be enlarged at a cost of about £350,000.

Limerick Dock Extension Scheme.

The Limerick Harbour Board has decided to apply for a provisional order to enable them to construct a new West entrance to the harbour, in completion of their dock extension scheme. Under the Harbour Act of 1926, a term of 10 years was allowed for carrying out improvements, and this period has now expired.

Annual Meeting at Port of Gloucester.

The Annual General Meeting of the Sharpness Docks and Gloucester and Birmingham Navigation Company, was held at the Dock Office, in the City of Gloucester, during the middle of last month. The figures submitted for the year 1937 showed that Imports amounted to 713,200 tons and Exports to 35,863 tons, compared with 724,957 tons and 24,075 tons respectively for 1936. Receipts totalled £103,994 and Expenditure £54,307, showing a balance of £49,687.

Albert Canal nearing Completion.

Work on the Albert Canal, which was commenced in 1930, will be completed next year, when it will be opened to navigation. This new waterway is 122 kilometres (75¾ miles) long, and is navigable by sea-going vessels and the largest Rhine lighters, some of which measure up to 2,000 tons. The canal will connect Liege with Antwerp, so that the industrial area surrounding these towns will be in direct communication with overseas destinations.

La Plata to be Developed.

La Plata, which is situated 30 miles south of Buenos Aires, on the estuary of the River Plate, is to be made into a port, with sufficient depth of water to take ocean-going liners. Consent has been obtained from the Federal Government for dredging operations to be undertaken in the channel leading to the port. La Plata has a population of 182,000, and is the fourth city of Argentina.

Rapid Meat Cargo Discharge at London Docks.

A record for rapid discharge and distribution of meat cargoes was set up at the Royal Victoria Dock, London, when 1,647 tons was landed and delivered from the British steamer "Duquesa" lying at "Z" berth. This involved the handling of 22,460 quarters, 1,151 bags and 151 carcasses of chilled beef in 105½ gang hours, and was rendered possible by the mechanical equipment installed at the "Z" meat berth by the Port of London Authority.

Renewal of Dock Gates at Grimsby.

The London & North Eastern Railway are to put in hand the renewal of the dock gates at No. 1 graving dock adjacent to the Royal Dock, Grimsby. This graving dock is almost constantly in use, and to renew the dock gates in the normal manner would involve putting the graving dock out of commission for about four months. As this would cause very serious inconvenience to shipping, a method of renewing the gates has been devised, which will allow the dock to be kept in commission except for a few days when the gates are being stepped. A new gate is to be constructed and used to replace one of the existing gates, enabling the old gate to be taken away and completely renewed, after which it will be brought back to the graving dock to replace the other original gate. The work will be carried out departmentally, and the total cost is expected to be about £3,000.

Novel Vessel on Ferry Service.

What has been described as the "Crab Ship," the new Diesel-engined vessel "Lymington," constructed for the Southern Railway service between Lymington and the Isle of Wight, was launched at the beginning of last month, at the Leven Shipyard of Messrs. William Denny and Bros., Ltd., Dumbarton, the builders of the vessel. The ceremony was performed by Mrs. R. P. Biddle, wife of the Docks and Marine Manager of the Southern Railway. The vessel gets its nickname from the method of propulsion, which is by means of two propellers of the "Voith-Schneider" type. The manœuvrability of the vessel will be such that it will not be necessary to have rudders; in other words, if necessary, the vessel will be able to proceed side-ways, a great advantage, having regard to the restricted conditions in which it will have to work. It is the first vessel to be propelled in this way in British waters.

*Estuary Channels and Embankments**

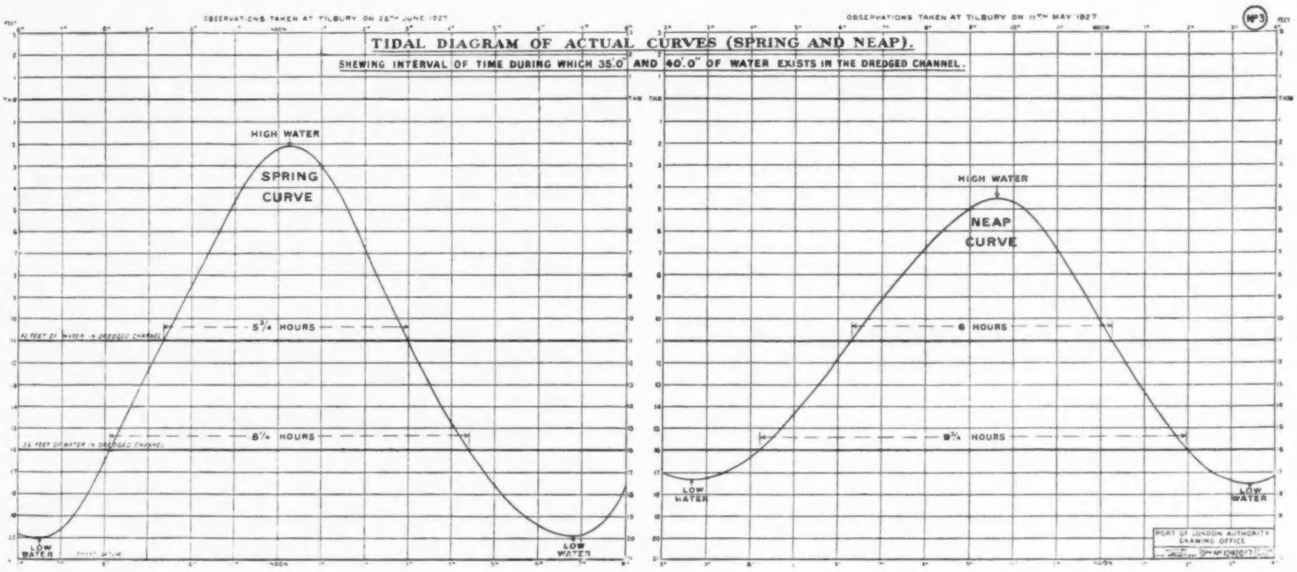
By BRYSSON CUNNINGHAM, D.Sc., B.E., F.R.S.E., M.Inst.C.E.

Introductory

THE treatment of rivers for the improvement of their channels, the regulation of their flow and the protection of the adjacent land from periodical flooding provides for the River Engineer a range of interesting and attractive problems, some of which, indeed, can be very complex and involved. As, therefore, the entire field of river engineering is too extensive for effective consideration in a single lecture, I propose to invite your attention this evening to that part of it which is concerned with the river mouth and its adjacent reaches, or, to use a term which is fairly comprehensive, the Estuary.

The Tides

While it is not practicable, and, indeed, scarcely germane to our purview, to discuss tides, their cause and characteristics, in this discourse it may be desirable to remark in passing for the information of those not fully familiar with the subject, that tides occur under the joint influence of the moon and the sun, in cycles, comprising alternate series of high and low peaks, designated Springs and Neaps respectively, over periods of a fortnight, i.e., half a lunation. The assistance of the tidal rise in enabling shipping to reach inland ports located on rivers of inadequate depth is of the greatest value, as can be illustrated in the case of the Thames by the accompanying graph, setting out the periods during which vessels of deep draught can come up the river to the docks.

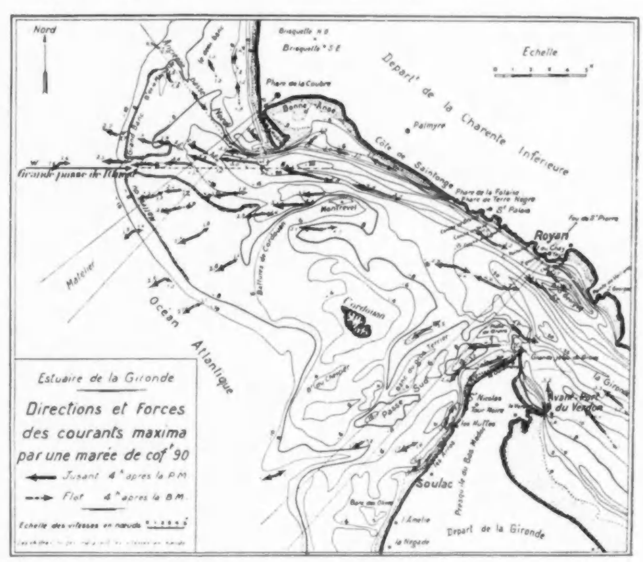


Thames Tidal Diagram.

A definition of the term Estuary, or rather the precise delimitation of its extent, is not altogether an easy matter. It would be difficult, even, to give a description of a typical estuary. In fact, it may almost be said that there is no such thing as a typical estuary: each estuary has its own peculiar characteristics, and no two estuaries are alike. The estuaries of the Thames and the Mersey, for instance, with which I have been most intimately associated during the course of my professional life, present in several fundamental respects features of the most striking, not to say violent, contrast. But most people have a fairly good idea of what is meant by an estuary, and it is used in common parlance without misconception, though in a technical sense, there are a number of aspects and qualifications to be borne in mind. The root of the word is the Latin Aestuare, to seethe or boil, and it obviously indicates a region of intumescense and turbulence, such as may be produced physically by the conflict and interaction of tidal and river flow when they are in opposition to one another. In other words, the estuary may be conceived as the tidal compartment of such rivers as are subject to tidal influence and to extend as far as the limit of palpable tidal action. But while the great majority of rivers in the world discharge into tidal seas, there are a number of important rivers entering seas, such as the Mediterranean and the Baltic, where tides are feeble and even inappreciable, the slight and relatively insignificant changes in level which are experienced being due to differences in barometric pressure and to wind action, rather than to any effect of the varying phases of lunar influence. In locations of this kind, the estuary, considered as a tidal compartment, is very restricted in extent, even if it can be said to exist at all. Perhaps it is hardly justifiable to use the term Estuary in connection with such rivers, their mouths being subject to a regimen of an entirely different character, generally described as deltaic.

However, having made the distinction clear, I propose to use the word in a broad sense to signify the coastward section of a river which is to a greater or less extent invaded periodically by the sea and is subject in an appreciable degree to tidal phenomena. As all British rivers are tidal, as well as the important Continental influents into the North Sea, the English Channel and the Atlantic Ocean, there are a very large number of rivers in this part of the globe with mouths, or embouchures, to which the term Estuary is strictly appropriate.

The range of tidal action may be very considerable, both in height and extent. The spring tidal range in the Thames is of the order of about 20-ft., and the flow extends inwards as far as Teddington, a distance of nearly 70 miles from the Nore. It would extend even further but for the intervention of the Teddington Lock and Weir. The maximum tidal range of the Mersey at springs is nearly 30-ft., and it has an inward flow for about 46 miles. In the Bristol Channel, the tide rises on occasion to a height of about 40-ft. The Seine is under tidal influence for a distance of 90 miles and the Scheldt for a little over a hundred miles. In one of the world's greatest rivers, the Yangtse-kiang, the tidal rise is discernible in the winter as far



Currents at entrance of Gironde Estuary.

as Tatung (375 miles from the entrance), though reversals of current rarely occur above Chinkiang (200 miles up the river). The effect of the tides on the flow of water in estuaries is, therefore, of fundamental importance. At a high spring tide, the flow into the Mersey is no less than 710 million cu. yds., say 550 million tons, whilst into the Scheldt where there is a

* The 1937-8 Vernon-Harcourt Lecture of the Institution of Civil Engineers, delivered at the Institution on December 8th, 1937, and subsequently repeated at Manchester, Newcastle, Sheffield, Birmingham, Glasgow, Belfast, Cardiff, Bristol and Southampton.

Estuary Channels and Embankments—continued

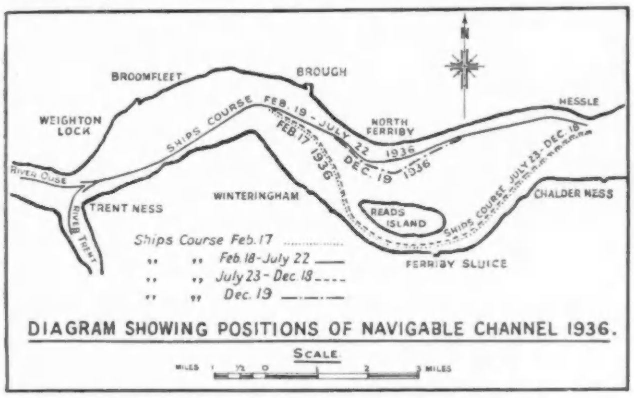
much more moderate range, it is 475 million cu. yds., or 366 million tons. The total flood wave entering the mouth of the Yangtse-kiang on a spring tide is computed at 300 thousand million cu. ft.

Having briefly outlined our purview, we may now proceed to consider the physical features of estuaries and the engineering treatment appropriate to their amelioration, the main objects of which are firstly, the regulation and improvement of the navigable channel, and secondly, the protection of adjacent low-lying lands from tidal inundation.

From the point of view of navigation, defects may arise from three causes:

(1) A shifting, unstable channel.
(2) A shallow bed, with inadequate depth of water.
(3) A bar.

We will proceed to discuss them in that order.

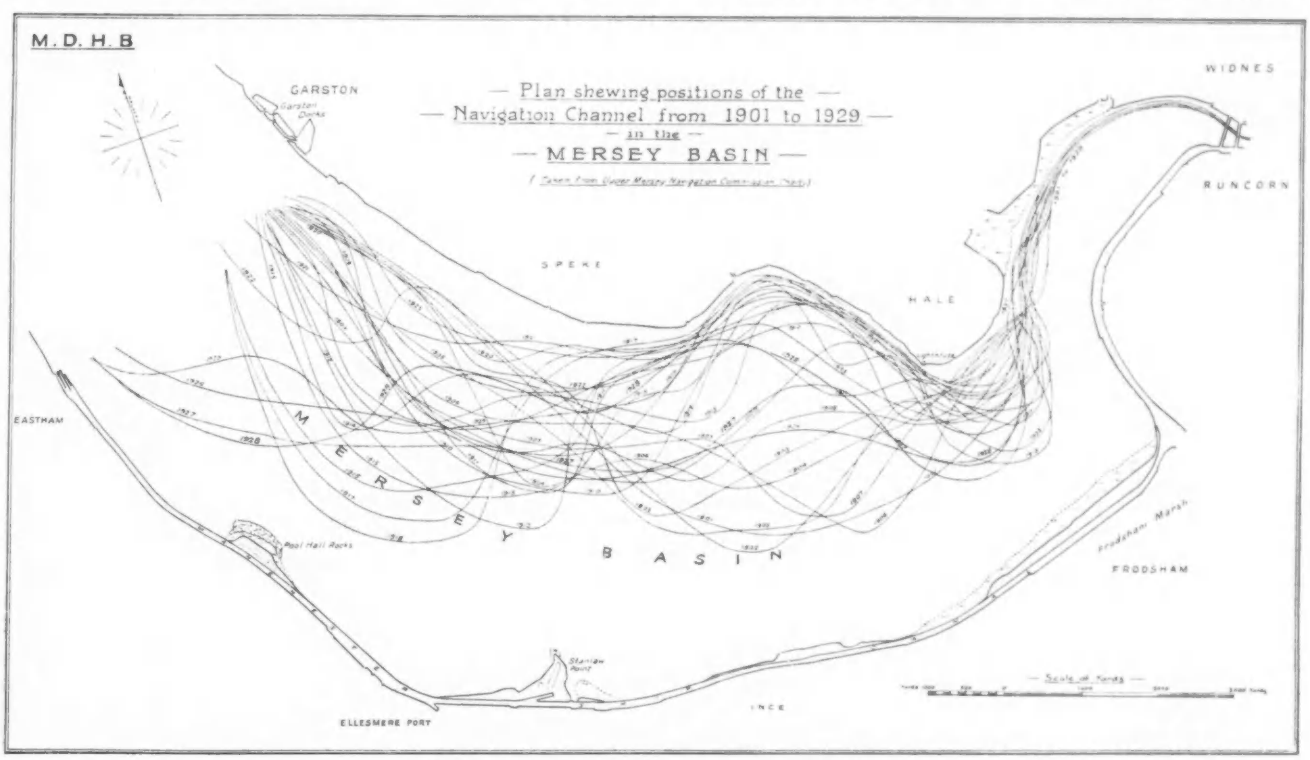


Variations in Ship Channel in the Humber.

UNSTABLE CHANNELS

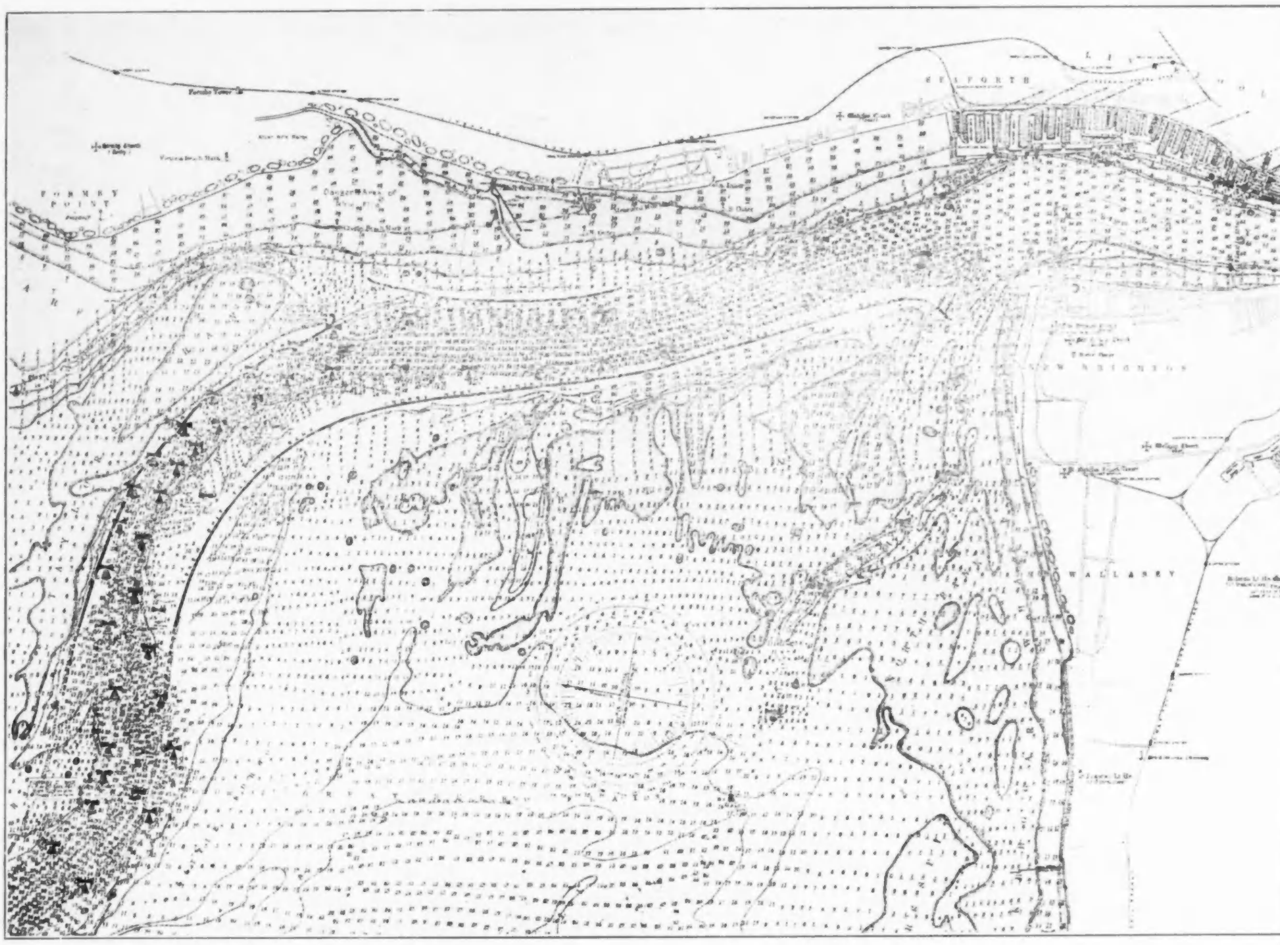
As regards (1), the estuary is essentially affected by the fact that the flow of water is never for more than a few hours at a time moving in the same direction. Twice, at least, in the majority of cases, within a period of about 25 hours, the natural outward flow of the river is held up and reversed by the great volume of sea-water which moves inland with a force and velocity sufficient to overcome the fresh water discharge. Then, after a brief interval, the outward direction of flow is resumed with an augmented volume, due to the addition of the upland water. This oscillating movement is extremely variable, not only in duration and amount, but also in regard to the course taken. The main body does not by any means necessarily follow the same route for ingress as for egress, nor does it identify itself with that of the fresh water discharge, nor again does it confine itself, especially near the mouth, to any particular part of the bed. The currents in and out of the Gironde Estuary are shown on p. 202. There are times when the tidal flow may be moving inwards on one side of the estuary, while the river flow is moving outwards on the other. I recall a remarkable demonstration of this fact in the estuary of the Mersey in February, 1895, on the occasion of an extraordinarily severe frost, which lasted for some weeks. The river was frozen over in places, and when the thaw came, a great and impressive procession of huge ice floes was set in motion, moving inwards with the tide along the right bank and outwards with the stream on the left. There is, furthermore, the consideration that owing to the higher specific gravity of sea water, the lighter river water may flow for some distance in a contrary direction over the surface of the heavier salt water. There are other irregularities due to wind action, to the occurrence of storms and to the effect of a heavy rainfall on the supply of water from inland. These numerous factors all tend to render the estuary a region of unstable channels, intersected by banks and shallows. To such an extent is this conflict of routes in evidence that a prominent feature of some estuaries is the existence of what are termed "blind channels," that is to say, deep depressions in the bed extending for some distance and terminating abruptly in a shoal or ridge. The Sloyne in the River Mersey is a notable example; others are the Bog Hole off Southport in the estuary of the Ribble, Mostyn Deep at the entrance of the Dee, and the Great Nore Channel at the mouth of the Thames. Even the navigable channel itself, called the "thalweg" by foreign engineers, is made up of a succession of depressions and ridges or shoals, the latter of which happen to be lower than any adjacent parts of the bed. These shoals, or ground sills, as they are sometimes termed, occur at inflexion points in the normally sinuous course of the river, that is, where there is reversal of the curvature. They are in places sufficiently elevated to constitute an obstruction to navigation, and accordingly call for treatment. A succession of such sills is to be found, for example, in the course of the Scheldt below the Port of Antwerp. The sills fluctuate in height, but by regular attention they are kept within the limits required by navigation. Also, from time to time, they advance and recede.

Unless checked, then, by artificial means, the navigable channel of an estuary has a tendency to change its position and direction in accordance with the natural forces at work. This is strikingly illustrated by the variations in the ship channel in the Humber during the year 1936, when between the months of February and December, the channel moved twice from the South to the North side of the estuary and back again. Similarly, in the Mersey, the channel is continually undergoing changes. Between Hale Head and Garston, the estuary is three miles in width, and on more than one occasion, the channel within a period of several months, has drifted right across the full width from the Lancashire side to the Cheshire side and back again. There was notably the "Great Fret" of 1873, when the roving stream eroded a course so close to the southern bank, that it wrecked the whole frontage of Ellesmere Port on the Cheshire side and then drifted over to the opposite bank. The chart below shows the extraordinary range of variations in the navigable channel between 1901 and 1929. The same tendency to drift has been experienced in the estuary of the Ribble, where, between 1917 and 1933, the deep-water channel beyond the extremity of the training works, moved from a central posi-



Positions of Navigable Channel in Inner Mersey.

Estuary Channels and Embankments—continued



Revetment of Entrance Channel to Mersey.

tion northwards, subsequently swinging southwards beyond the central line, then back again to the central area.

Remedial Measures

When we come to consider the remedial measures which can be adopted to deal with this roving tendency of the channel, obviously the first step which suggests itself is that of confining the ingoing and outgoing streams alike within the limits of a single fixed channel, so that the moving water may act as a concentrated scouring agent, particularly on the ebb tide, serving to clear the channel and keep it free from deposit of silt and detritus. In theory, this is sound enough, but the application of the principle is attended by certain risks and possibilities which much be carefully weighed and provided for.

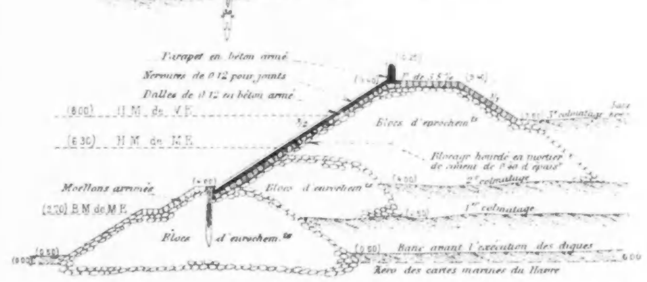
In the first place, it is essential to have a clear conception of the great value of the tidal water on the ebb flow. Obviously, the greater the volume of water admitted into the tidal compartment on the flood, the stronger and more effective will be the outgoing current on the ebb. Therefore any undue restriction of the tidal compartment must adversely affect the scouring agency.

Secondly, the natural and inevitable accompaniment of a confinement of the main flow of the estuary within a single channel is the gradual silting up of the rest of the estuary. In the case of the Mersey, the effect of such a concentration if carried out, would be to change fundamentally the whole character of the outlet. Should the roving propensity of the stream be checked, many hundreds of acres of land at present submersible would be reclaimed, with a corresponding reduction of the tidal water capacity and a consequent effect on the condition of the outer estuary.

But in a number of cases it is possible to contrive a scheme of training works which will have the desired effect of confining the main stream without seriously interfering with the beneficial tidal influence, though the works will have to be carried out cautiously and with a keen watchfulness on the results. It has been done in this country, for instance, on the Clyde, the Tyne, the Tees and the Ribble, and on the Continent, notably in the Seine.

Although it is difficult on account of the variation in local conditions to lay down definite rules for guidance in the carrying out of estuary training works, yet it may be indicated in a general way that a channel should be selected for treatment which, without undue constraint, follows the normal trend of the predominant tidal flow, whether ebb or flood, and into the same channel the river flow, should it pursue an independent course, should be directed.

In the latter event and perhaps in most cases, except where the maximum spring tide flood current exceeds the combined ebb and run-off, it is desirable to commence the works at the head of the estuary and progress seawards.

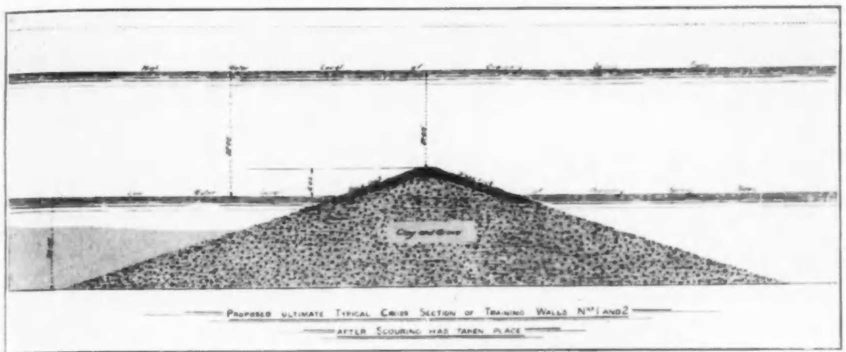


Sections of Training Walls in Seine.

The walls will be given a flare, or divergence, which as regards the river flow, will correspond to the enlargement of the catchment area, but will also take into account flood discharges and the tidal influx. The ratio of divergence varies considerably in different rivers; the larger the river the greater the divergence. In several Western European estuaries it lies between 1 in 50 and 1 in 100. Dr. Herbert Chatley has discussed the ratio in connection with the Whangpoo and Yangtse Rivers, and stated it mathematically in his Paper to the Institution on "Problems on the Theory of River Engineering"*.

*(Selected Papers No. 71).

Estuary Channels and Embankments—*continued*



Cross Section of Ribble Training Wall

In accordance with the normal sinuous course of rivers the channel should be given such curvature as the local conditions require. In rivers flowing along alluvial beds, Fargue,* publishing the results of his researches on the Garonne in 1909, pointed out that straight lines are the exception and present most difficulty to navigation, while in the curves are to be found better depths and more stable beds.

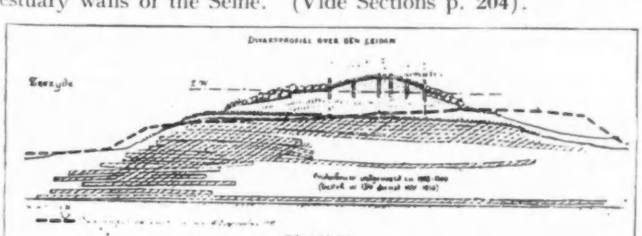
The mouth of the estuary will be trumpet-shaped, but should not be enlarged so abruptly as to cause too rapid contraction of the entrant tidal stream, lest this should give rise to the formation, or the accentuation, of a tidal bore, i.e., the generation of a wave rising several feet above normal water level and moving up the river with considerable rapidity.

Training Works

The means whereby estuary channels can be stabilised and regulated comprise the use of groynes and the formation of training walls, with or without the aid of dredging operations, though, in a number of cases, dredging is relied on entirely to maintain the navigable channel. In sandy estuaries, however, dredging cannot be expected to produce any improvement of a permanent nature.

The use of groynes in the form of timber piling or stone mounds, or fascine work, projecting like spurs at definite intervals from the bank into the bed of a river is generally confined to the inner sheltered reaches, where the groynes serve as a useful preliminary measure for the rectification of an erratic stream without undue repression at the outset. The effect is to cause accretion in the intervening embayments, but groynes also tend to produce local scour and eddying. Therefore, although useful as a temporary expedient leading up to the formation of works of a more complete and continuous character, they are of secondary importance, and it is not proposed to discuss them at length.

Training " walls," the main form of artificial works, are, strictly speaking, not walls at all. In the majority of cases, they are simply mounds of rubble stone deposited along the side of the channel which it is desired to regulate. Sometimes the deposit is no more than a mere revetment, or rough surface pitching, over the sloping sides of the channel, as in Liverpool Bay (vide Chart p. 204). In other cases, the wall stands up to some height in a wedge-shaped section with a broad base. The embankments at the mouth of the Venetian Lagoon will serve as an example of such mounds. In more elaborate undertakings, the mound is carefully set and faced with dressed stone and provided with a coping, as may be exemplified by the outer estuary walls of the Seine. (Vide Sections p. 204).



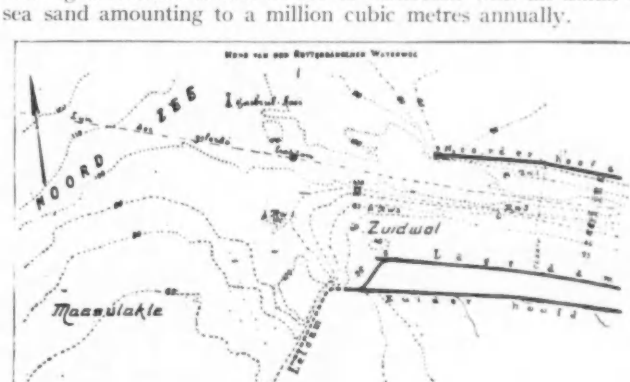
Cross Section of Training Bank with fascine mattresses.

The deposit of the stone rubble is not unattended by difficulties. Under water, it is scarcely practicable to secure accurate alignment, and if the floor of the estuary is at all soft or compressible, as indeed is generally the case, the rubble has a tendency to sink into the mud and sand, resulting in loss of material which has to be made good. In minor operations the stone is tipped overboard from punts and lighters, but deposit from hopper barges is the more expeditious and economical procedure for important undertakings.

In situations where supplies of rubble stone are not available, slag may be used, or even a mound of clay and gravel, provided it is protected from erosion on the face by a coating of stone. Or again, especially where the bottom consists of quicksand, incapable of supporting a heavy load, the walls may be constructed of fascine work, consisting of " mattresses " of brushwood, a method very commonly in use in the Netherlands; or of faggots or kids, as they are termed in Lincolnshire, of the same material, but smaller in size and more easily handled. The interstices of the fascines become filled in a very short time with a deposit of earth and detritus, which soon solidifies, so that the whole mass becomes a tough composite bank, with a certain degree of flexibility, enabling it to settle without fracture. It has been observed that there is less tendency on the part of fascines to slip out of position than there is on the part of stone deposits.

Mattresses were largely used for forming the dykes or training banks at the mouth of the Port of Rotterdam New Waterway, as it is still called, though it was opened to traffic as far back as 1868. The plan below shows the outer extremities of the dykes, the interior training works of the waterway consisting largely of a series of groynes, projecting from both banks. The navigable channel has just been widened from 280 metres (918-ft.) to 350 metres (1,140-ft.) by dredging away the submerged ends of the groynes on the southern bank, the remaining portions being built up to mean low water level. The depth in the channel now provides a passage for shipping up to 38-ft. at high water and 33-ft. at low water. The curious fact has been communicated to me by Dr. Van Veen of the Netherlands Rijkswaterstaat that during the whole period of the tide there are strong undercurrents due to differences of salinity, the surface and undercurrents moving in opposite directions, and causing a residual inflow as far as Schiedam with an influx of sea sand amounting to a million cubic metres annually.

Depositing a fascine mattress.

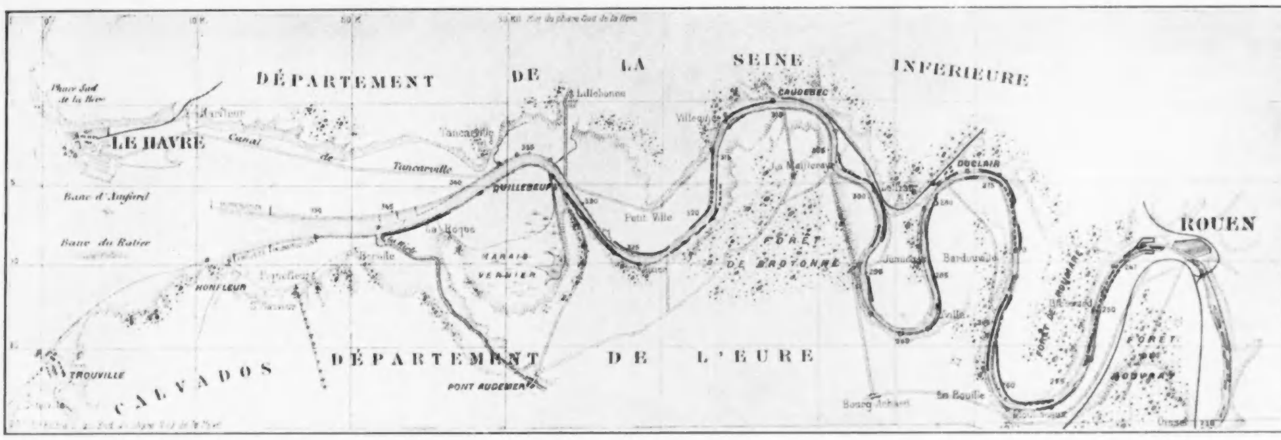


Training Works at entrance to Rotterdam "New Waterway."

One very serious possibility must be taken into consideration prior to the adoption of a programme of training by means of walls. Their essential permanence, once they are constructed, should induce prolonged reflection before embarking on schemes which, if they are ill-founded, may entail disastrous consequences. Such consequences have occurred in the past and have proved irremediable. Every care then should be taken in making the fullest investigation of the local conditions and in

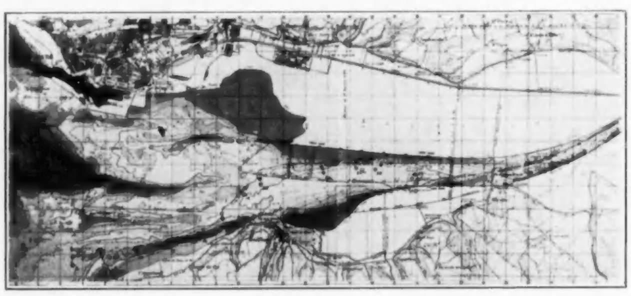
*La Forme du Lit des Rivières à Fond Mobile.

Estuary Channels and Embankments—continued



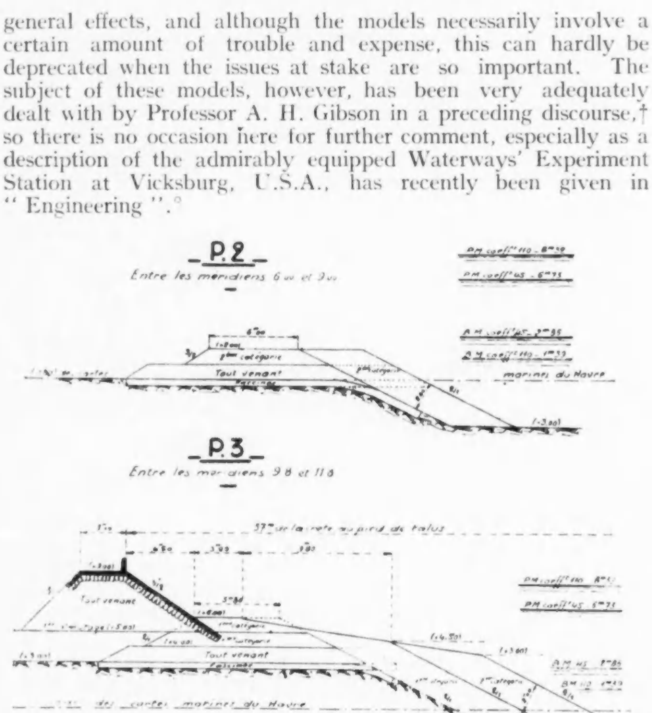
The Lower Seine.

estimating their influence on the works proposed. In this connection the use of tidal models, for which the late Professor L. F. Vernon-Harcourt, the founder of this Lecture, was an ardent advocate, as also a pioneer investigator, has demonstrated possibilities of considerable value in the indication of



The Seine Estuary (Revised Scheme).

general effects, and although the models necessarily involve a certain amount of trouble and expense, this can hardly be deprecated when the issues at stake are so important. The subject of these models, however, has been very adequately dealt with by Professor A. H. Gibson in a preceding discourse,† so there is no occasion here for further comment, especially as a description of the admirably equipped Waterways' Experiment Station at Vicksburg, U.S.A., has recently been given in "Engineering".°



Training Walls on South side of Seine Estuary.

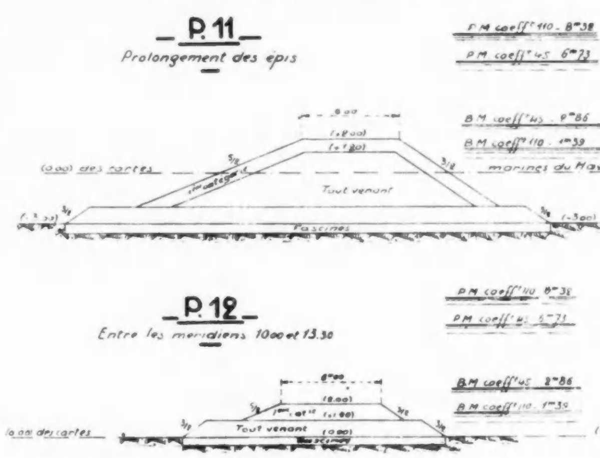
It is not always necessary to construct training works on both sides of the channel. If the main object be to protect erosion on the concave side of a bend, a single wall along the outer bank will probably suffice to confine the flow. An instance of this is afforded by the training wall constructed in the Rangoon River, and described in a Paper read before the Institution in 1916 by Sir G. C. Buchanan.‡

The River Seine

At this point we may find it useful to consider the example of the improvement works on the River Seine, which, as will be seen from the plan above, has an exceedingly tortuous course for the whole 78 miles of the distance from Rouen to the sea.

Prior to 1848, the untrained estuary, which extended as far as La Mailleraye, had a width of over a thousand yards between La Mailleraye and Villequier. It increased therefrom to a width ten times as great just above Honfleur. Over this vast area of bed, the channel took its sinuous and variable course with a depth of water which never exceeded 14½-ft. at spring tides and dropped to 5½-ft. at neaps.

Training works were begun in 1848, with the object of securing a better propagation of the tidal flow, and therewith the deepening and stabilisation of the channel. The earliest training walls between Villequier and Tancarville resulted in the fixation of the bed as far as the mouth of the Risle. Between 1867 and 1895, local improvements were effected above La Mailleraye.



Training Walls on North side of Seine Estuary.

Then, in 1896, work on the outer training works was resumed, and the walls were gradually extended beyond the Risle towards the mouth, reaching on the North side, approximately, to the meridian of Gonfreville, and on the South side to that of St. Sauveur. This was the position in 1920, since when there has been a change of policy.

The revised scheme now in hand in the estuary in consequence of the Act of 11th January, 1932, shown in the plan (above, left), is designed to increase the depth of water for shipping so as to give 8 metres (26¼-ft.) at Neaps and 9½ metres (31-ft.) at Spring Tides. The works comprise the creation, starting from a point near the confluence with the Risle, of a new South training wall linking up without detriment to the existing upstream river embankment. The new wall will describe a concave curve of considerable radius, and will be driven through the alluvial foreshore so as to pass within 300 metres of the extremities of the jetties of the Port of Honfleur. It will be prolonged downstream of that port in a direction slightly to the North of the Ratier Bank, with an opening opposite the Villerville channel. Sections of the type of wall adopted for the North and South sides of the Estuary are given on this page.

For the purpose of excavating the formidable mass of saltings between the old and new lines of wall, the authorities of the Port of Rouen have just acquired a large new suction dredger, the "Victor Guilloux," 91 metres (298-ft. 6-in.) long overall, and 15 metres (50-ft.) beam, with a draught of less than 4 metres (13-ft.), capable of working in the shallows at low water.

† "Tidal and River Models," Vernon-Harcourt Lecture, 1935-6.
° Aug. 20; Sept. 3, 10; Oct. 1.
‡ Proc. Vol. CCII.

Estuary Channels and Embankments—continued

It has a hopper capacity of 1,000 cu. metres (400 cu. yds.) and is also equipped with a discharge pipe line extending to a distance of 1,000 lin. metres. The pumps are operated by Diesel motors of 700 h.p., the vessel being capable of dredging at a speed of 2 knots against a current of 5 knots, and filling the hopper with sand in half-an-hour.

Before the execution of these works, only vessels drawing less than 10-ft. were able to ascend the Seine on favourable tides. Even this ascent was rendered difficult and sometimes dangerous by the action of the Mascaret, the equivalent of the English Bore, or tidal wave. The ascent required a minimum of 4 days, the ship having to ground at low water and re-float on the return of the flood.

At the present day, the Mascaret is no longer a menace to navigation, the slight intumescence still in evidence causing no inconvenience. The available depth in the lower Seine is practically 20-ft. at every tide; at springs it reaches from 23-ft. to 26-ft. A tanker has reached the Port of Rouen with a draught of 26-ft. 4-in. Naturally, the passage of shipping is aided by the tide, the duration of the journey (6 to 7 hours on an average) being slightly longer than that of the propagation of the tide, which occupies from 5¾ to 6¼ hours.

(To be continued).

British Canal Prospects

An Optimistic Outlook

At the 38th Annual Dinner of the Institution of Engineers-in-Charge held on April 8th, with Mr. Asa Binns, M.Inst.C.E., Chief Engineer of the Port of London Authority, presiding over a large attendance, prominence was given to the subject of British Canals and Inland Waterways, in a Toast proposed by Dr. Brysson Cunningham and responded to by Mr. E. J. Woolley, M.C., Chairman of the Grand Union Canal Company.

In the course of his remarks, Dr. Cunningham said that he did not share the defeatist views of those who maintained that the days of canals were over and that the best thing to do with them was to fill them in and convert them into roads. He pointed out that neither in the 1909 Report of the Royal Commission on Canals and Inland Waterways, nor in the 1921 Report of the Chamberlain Departmental Commission, nor yet again in the 1930 Report of the Royal Commission on Transport, was a pessimistic view taken of the prospects of canal transport in this country. To quote only from the last-named Report, after an admission that for reasons of past neglect there was in some cases little prospect of successful revival, it was stated: "Nevertheless, we are of opinion that certain canals still possess considerable value as a means of transport, and that, properly rationalised and developed, they can be made to render much useful service to the community in the future." He urged this sane and balanced view as justification for the Toast, which he trusted might be taken to connote the desirability of Government aid in order to foster and develop British Inland Waterways. In certain directions much had already been done in developing these waterways by private enterprise, and the Grand Union Canal Company could not be too highly commended for their courage and initiative in bringing about an amalgamation of the various undertakings along the route between London and the Midlands, improving and enlarging the waterway at considerable outlay and making it a conspicuous example of successful administration. Quite apart, moreover, from purely commercial considerations, there was in the minds of far-sighted people an appreciation of the valuable service which could be rendered by canals in time of war as an alternative means of internal transport.

In Germany, the waterways ranked in importance next after the railways, and they handled between 80 and 100 million tons of goods traffic annually, as compared with 11 or 12 millions in this country. Considerable and unfailing enterprise was being shown in developing these waterways, both by the canalisation of rivers and by the construction of connecting canals. A notable instance at present in hand was the Mittelland Canal, extending from Hanover to the waterways of the Elbe-Oder area, and so linking up Ruhrort on the Rhine with Hamburg at the mouth of the Elbe. It would be completed in 1942, and would be able to deal with craft up to 1,000 tons capacity. In contrast with the Lilliputian units in Great Britain, called monkey boats, having a load capacity of only 30 tons, the 1,000 tons boat was being adopted as a general standard throughout Germany, while on certain routes even higher standards were being attained. Barges of 1,350 tons traversed the Lippe Lateral Canal, while on the Upper Rhine, between Strasburg and Basle, the vessels were of 2,000 tons burden. Of the total national goods traffic, 27 per cent. was carried by water, and one-third of the exports sent to ports for shipment travelled in this way. There was a fleet of craft aggregating over 18,000 vessels, with a gross capacity of 6½ million tons and 750,000 h.p.

The same tale was told in other countries. One of the most remarkable examples of recent canal construction was the Twente Canal in Holland, opened in 1936. It is 75 miles long and can take barges of 1,350 tons dead weight. Belgium is at present constructing the Albert Canal, which will have a depth of 16½-ft. and be able to accommodate Rhine barges of 2,000 tons capacity. Russia has just completed a magnificent feat of engineering in the Moscow-Volga Canal, transforming Moscow into an inland port.

It would no doubt be objected that conditions on the Continent were in many respects different from conditions in this country. There were long expanses of fairly level country suitable for canal construction, and there was an absence of that proximity to the coastline which most industrial centres in Great Britain enjoy; but when all was said, there remained a pressing and inexorable need to rescue British inland waterways from the slough of neglect into which many of them had fallen, and to restore them as far as possible to useful national service. It is because so excellent a lead had been given in this direction by the Grand Union Canal Company that he was privileged to couple the Toast with the name of Mr. E. J. Woolley, the Chairman of the Company.

Responding, Mr. E. J. Woolley quoted appreciatively certain extracts from the letter of invitation he had received from the Honorary Secretary of the Institution (Captain Penn), who had referred to canals as " beautiful natural assets which are not receiving their due " and " grand possessions which should be used to the utmost, both in war-time and times of peace." When the speaker thought of the ignorance displayed by certain other people who considered themselves qualified to write on the subject, he was reminded of an old Chinese proverb, which ran: " If only men spoke on subjects of which they had knowledge, how profound would be the silence! "

Important changes had taken place in canals in the last few years. No longer would be seen the horse-drawn boat pursuing its leisurely course in charge of a bargee more famed for his language than anything else. Instead would be seen boats propelled by 18 or 20-h.p. Diesel engines in charge of men who had knowledge of mechanics. No longer did the journey take eight or nine days, for the same voyage could now be accomplished in some 72 hours and, if occasion required, in 60 hours. Not so long ago a pair of boats went from London to Birmingham in the short space of 48 hours. A great deal had been heard about a new boat of 14-ft. beam. If such boats could be put on English canals there would be a great advance in methods of transport, but at present it was out of the question. The numerous systems in the country were all constructed on different principles. The locks were mostly made for the small narrow boat, and to convert them to accommodate the larger boats would cost many millions of pounds. The Grand Union Canal Company traded over a system formerly owned by six different companies, on only one section of which big boats could navigate.

Canals bore a very close relation to the great docks and harbours of the country. Most of them originated at one or the other, but it was not always the case. A great many undertakings were amalgamations of small concerns, originally built to carry local traffic, and, as the need for long-distance traffic grew, so these various units were linked together to form one big system. This was exemplified in the case of the Grand Union Canal, which was an amalgamation of eleven separate undertakings, and it had been carried a step further, for it had its own shipping company trading between the Continent and the Company's dock in the Port of London. Recently, the Grand Union Canal Company had formed a carrying company in Belgium, which now traded over the whole system of European canals with large barges ranging from 460 to 1,000 tons, so that the Company were in a position to carry goods from the centre of England into the heart of Europe by an all-water route, without touching road or rail.

The tonnage carried by British canals was developing, and in the last two years had increased by some 450,000 tons. Last year the Grand Union Canal Company had to refuse some hundreds of thousands of tons because of the impossibility of finding experienced men to man their craft. This showed that canals in this country were far from dead.

Proposed Extension of Manila Harbour.

The Bureau of Public Works of the Philippine Islands Government has in hand a scheme for developing the harbour accommodation at Manila. An important feature is the reclamation of the north portion of the bay to provide sites for rehousing schemes for the capital. A sum of P2,500,000 will be required for reclaiming approximately 200 Hectares of foreshore. The complete plan for the proposed North Harbour includes the construction of a breakwater extending from off the north bank of the Pasig River to a point in Manila Bay off the mouth of the Estero de Vitas, where a basin will be provided for fishing craft. The site of the new harbour will be dredged to a depth of 26-ft., and the material used for filling the reclaimed area.

*Dunkirk Harbour Extension Works**

By L. P. BRICE

DUNKIRK HARBOUR is one of the principal transit points between England and France. Its position, moreover, is remarkable; seawards, its entrance channel opens on a bay crossed by international steamship lines, landwards, it is connected with France, Belgium, Germany, Switzerland, Italy, and other countries by a system of railway lines and canals all converging towards it. (See Fig. 1).

The history of this harbour goes back as far as the very origins of the history of our country. The coastal district was occupied by the Romans, then as early as the fourth century B.C., it was flooded, and it was not until about the year A.D. 800 that the district could again be inhabited. A fishing hamlet soon appeared at a spot on the coast where during the flooded period the running waters gathered. A chart of 1067 shows for the first time the name of "Dunkerque," as it is to-day spelt in French, while the designation of "Dunkirk" is more familiar to the English-speaking public. It will be remembered that "Dun" stands obviously for "down" and "kirk" will no doubt sound familiar to Scottish members of this audience. The coat-of-arms of Dunkirk have always shown a large flat fish. However, for centuries this town, the importance of which was already beyond question, had to withstand many sieges and bombardments. Between 1300 and 1712, the fortifications were rebuilt several times, owing either to destruction or to extensions of the harbour, which was then a typical example of the classical type of fortified harbour, namely, a girth of high walls around a mass of houses heaped one close to the other, with the quay extending outside at the foot of the wall, the moat being, moreover, provided for the drainage of the hinterland.

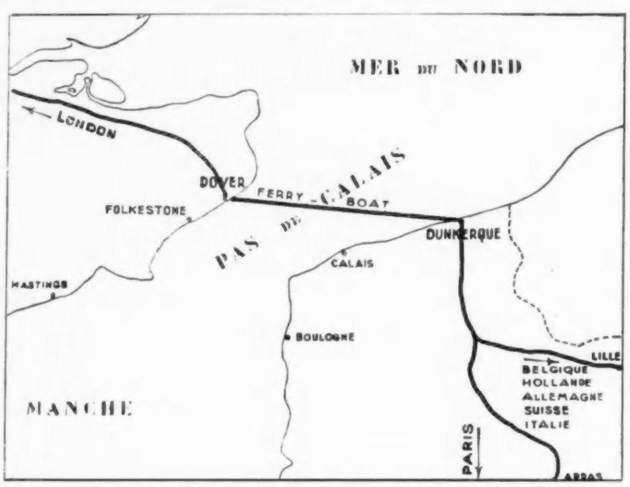


Fig. 1.

On the eve of the French Revolution, Dunkirk, after various ups and downs during the struggles between England and France, had become one of the greatest harbours in the world. The French Revolution and the Empire struck a fatal blow to Dunkirk—since Napoleon preferred Antwerp.

During the course of the nineteenth century, the traffic was slowly but surely reorganised, and constant improvement was effected.

In 1820, the number of vessels coming into or setting out from Dunkirk was 1,449, representing a total tonnage of 105,958 tons.

In 1871, 6,728 ships carrying 1,149,144 tons of goods were registered. In 1930, the total was five million tons of goods for a gross tonnage of ships of 12 million tons.

Extension and equipment works had to be undertaken during the War, and it is hardly necessary to remind a British audience of the spirit of comradeship which then united Dunkirk sailors and the Dover patrol. The Commander of the Dover patrol paid a splendid tribute to the memory of the greatest sailor of Dunkirk, Jean Bart, when passing in front of his statue one day, he said: "It is fortunate that Jean Bart is not in command of the enemy fleet as we should rarely have a night in our beds."

* Paper read before a Joint Meeting of the Institution of Structural Engineers, the Institution of Civil Engineers and the British Section of the Société des Ingenieurs Civils de France, at the Institution of Civil Engineers, Great George Street, London, S.W.1, on 1st February, 1938.

It was immediately after the War, however, that the present extension programme was framed. (Fig. 2).

It was the Act of October 22nd, 1919, which laid down the main lines of the programme, based on the one hand on the experience of the Great War (suppression of fortifications) and on the other hand, on the project of the chief engineer,

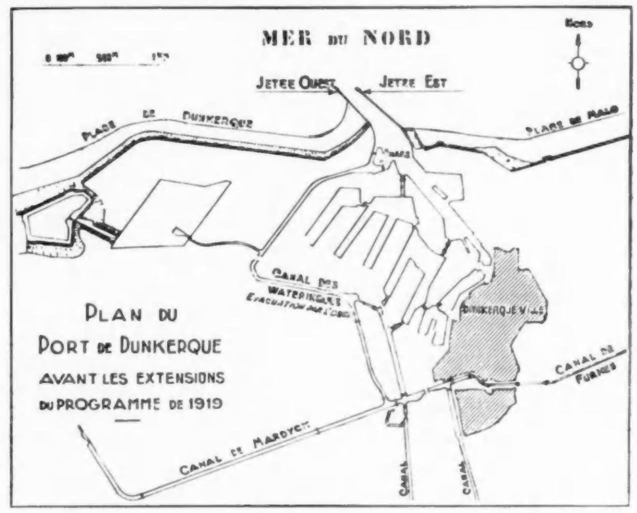


Fig. 2.

M. Bourgeois, by which the problem of disposal of the so-called "Wateringues" waters was solved by the construction of a single exhaust east of the town, that is to say, on the side where the growth of increasingly important suburban boroughs prevents any future extension of the harbour. (Fig. 3).

The lay-out of the projected works is such that Dunkirk will now have the characteristics of a harbour with converging entrance. Since the sand is normally blown from west to east, it was imperative that the west wall should be solid, in order to present a continuous obstacle to the shifting of these sands.

In this way the development of the west side of the harbour gave the town a perfect geometrical figure, logically planned and free of limitations.

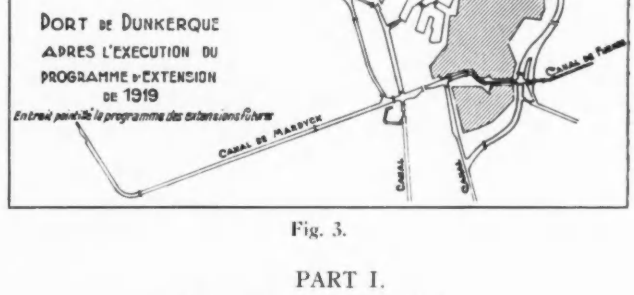


Fig. 3.

PART I.

Nature of Extension Works

The programme of extension works made compulsory by the 1919 Act included:—

1.—The extension of the present eastern breakwater up to (−8) metres level, by means of an open work breakwater 700 metres (2,296-ft.) long.

2.—Building of a new solid western breakwater, 750 metres (2,460-ft.) long, laid out at an angle of about 98° with the eastern breakwater and leaving an entrance of 210 metres (689-ft.) between the ends of the two breakwaters.

Dunkirk Harbour Extension Works—continued

3.—Connecting the western breakwater with the land by means of a sea wall.
4.—Building a sea wall south of the new lower harbour.
5.—Building a marine lock, laid between the southern sea wall of the new lower harbour, and the northern wall of the docks including the present pier V and the projected pier VI.
6.—Building of a training jetty seaward and west of the wall.
7.—Building East of the lock in the lower harbour a berthing jetty.
8.—Excavating the ingress canal of the lock.
9.—Forming up behind the sea walls and berthing jetty of the reclaimed ground, by means of excavated materials taken out of the docks.
10.—Fitting a new berth for the ferry-boat.
11.—Opening a connection between the new marine lock and the already existing docks.
12.—Sundries, such as lighthouse, various building, etc.

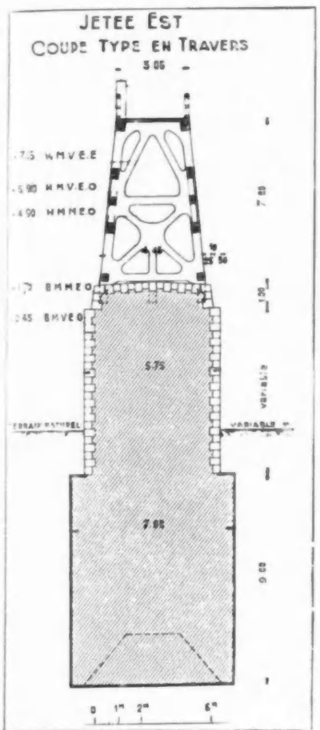


Fig. 4.

The works have included the principal following quantities:—

Excavation by compressed air 50,000 cu. metres; excavation in open air 250,000 cu. metres; excavation under water 900,000 cu. metres; dredging in sea 1,400,000 cu. metres; filling 1,500,000 cu. metres; basket work 40,000 sq. metres; stone pitching 180,000 tons; concrete blocks 35,000 cu. metres; sundry concrete works 250,000 cu. metres; steel piling 20,000 tons.

The lay-out projects concerning these extension works have been prepared by the Ponts et Chaussées under the supervision of the chief engineer of the Dunkirk Harbour, M. Broquaire and his assistants MM. Etienne and Delattre.

The first nine items above were allotted on May 31st, 1929, to Messrs. Sainrapt et Brice, together with the German firms of Messrs. Polensky & Zollner, and Messrs. Wayss & Freytag, the two latter firms working on reparations account.

We wish to give here a special mention of appreciation to these two firms and to the perfect competence of their directors, Pr. Mautner, Dr. Werner Ehrenfeucht and their engineer, Mr. Fiederling.

The last three items were one after the other entrusted to Messrs. Sainrapt & Brice, who are now completing them.

1.—**Eastern Breakwater.** The new breakwater is composed essentially of an open work, similar to the breakwater of the Calais western breakwater, built up from level (+9) metres, level of the gangway, down to level (+2) metres, where is is inserted in a solid masonry work, resting on lost caissons, sunk by compressed air.

The level of the foundation varies from (−8.50) to (−17.30) below the level of the lowest tide, that is to say, zero of marine chart.

The caissons are 6 metres wide, for those sunk down to (−13.60), 7 metres for the others, with the exception of the end caisson which is 8.50 metres wide.

The facings of the foundation block are vertical up to level (+1.00) when a recess is provided, above which the facings are tapered 1/10 up to (+2.00), level at which the solid masonry is finished off with a convex profile of 0.15 metre camber.

The above-mentioned recess is designed to compensate the variations due to the sinking and to allow a strictly rectilinear lay-out of the upper structure.

The foundation block is 5.75 metres wide and includes a facing of artificial stone, the inside is filled with concrete.

The upper structure is made up of reinforced concrete trussed girders, 7 metres high, and 3.05 metres wide at the top. The distance between the centre lines of two girders is 3.50 metres. (Fig. 4).

The outside stanchions of the girders are tapered 1/10, they are connected between themselves, perpendicular to the axes of the breakwater, by ties and struts and longitudinally by lierne vaults and cross members.

The gangway is also in reinforced concrete, its free width is 2.75 metres, the railings in reinforced concrete are 1 metre high. Ladders and bollards are provided for the equipment.

At the head, the gangway is 5 metres wide, on a length of 14 metres.

The eastern breakwater was begun in 1931 and completed in 1934.

Fig. 7.

2.—**Western Breakwater.** The new western breakwater has been built at 2,300 metres west of the old one, which formed the old entrance channel.

The lay-out of this breakwater is such that it is directly exposed to westerly currents and winds.

Owing to the unsatisfactory nature of the ground on which the work stands a solid construction was necessary.

On about 235 metres from its root, the breakwater is of the vertical type. The foundation is formed up below level (+3), by a solid block of concrete poured between two curtains of sheet piling, 6.50 metres apart and connected between themselves, from place to place, by other similar curtains, the whole constituting a row of compartments (Fig. 5).

The foundation level varies from (−1) to (−3) metres.

The upper structure includes a solid mass of concrete 5.70 metres long, at the bottom, with facings tapered 1/10 in artificial stones (Fig. 6). The top, which is 4.50 metres wide, is levelled at (+9) metres and fitted seaward by a wall 1.20 metre wide and 1.50 metre high; an inside gallery allows the access to the head in case of bad weather.

Beyond the first 235 metres, the breakwater is of the ordinary type with foundations resting on a bed of stone pitching. Owing to the risk of underwashing, the stone pitchings (100 to 1,200 kg.) rest on a bed of basket work 1 metre thick resting on bottoms from (−1) to (−8.50) metres.

Stone pitchings are levelled to (+1) and are recovered with artificial concrete blocks, weighing 50 tons.

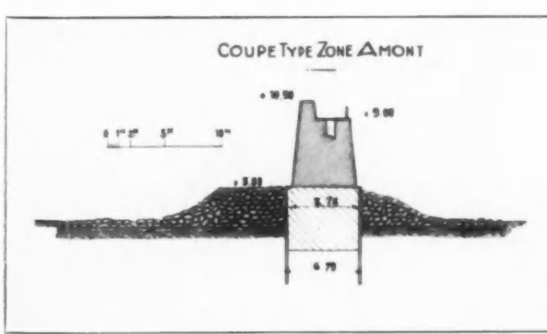


Fig. 5.

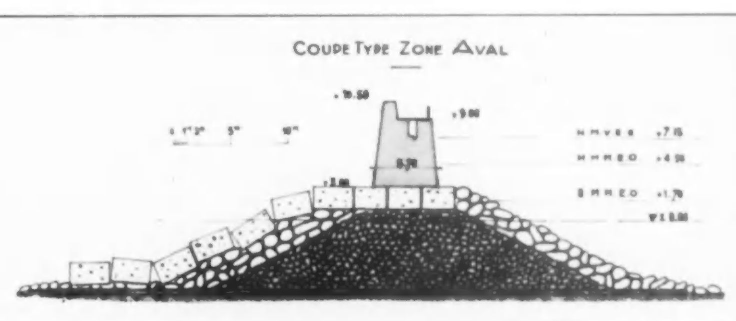


Fig. 6.

Dunkirk Harbour Extension Works—continued

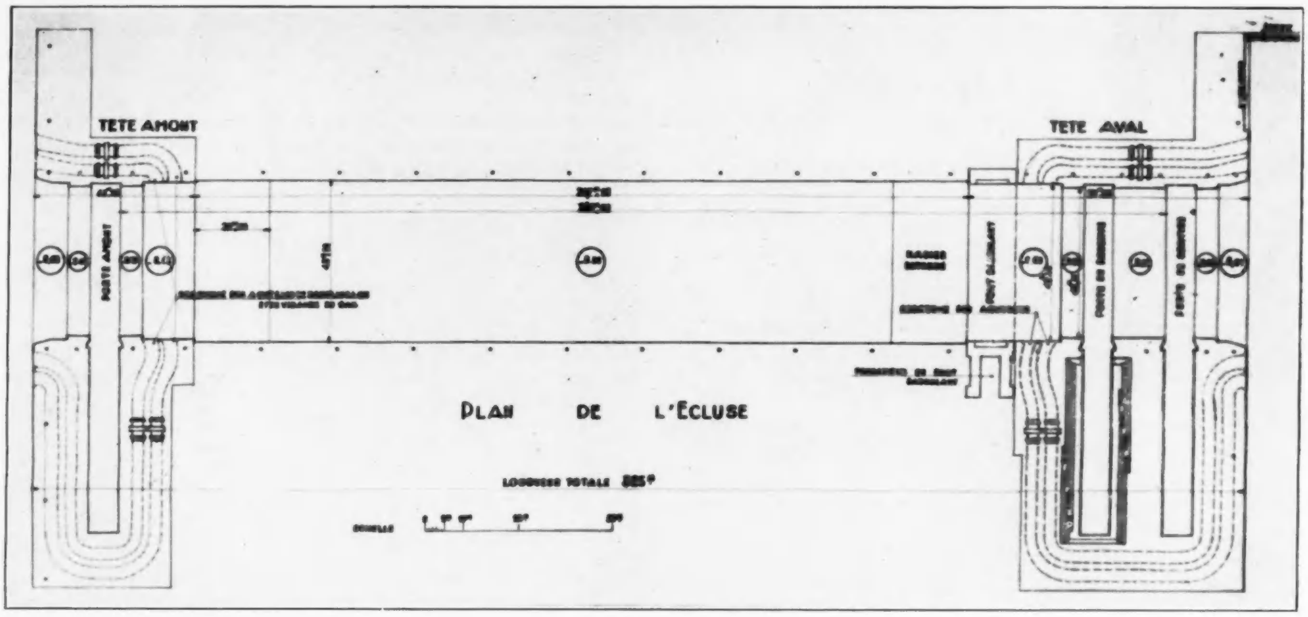


Fig. 9.

The stone pitching slopes are covered with a layer 2 metres thick of larger pieces (1,000 to 5,000 kgs.) with a slope 2/1 seaward and 3/2 inward. The large stone pitchings are themselves covered with 50-ton blocks around the head.

Above the (+3) level, the upper structure is similar to the one described above.

This head has a free width of 8 metres and is 18 metres long.

These works have been just completed, but the western breakwater has not yet been open to the public.

Fig. 8.

3.—**Marine Lock.** It is intended that this lock shall join the new lower harbour formed by the eastern and western breakwaters to the upper harbour already existing and constituted of a row of tidal docks (Figs. 7 and 8).

This lock will also connect with the future extensions of Dunkirk Harbour, which, according to the present programme, are not to be carried out for the time being.

It was therefore imperative that the dimensions of this lock should be sufficient to satisfy the requirements of the near future (Fig. 9).

The total length is 325 metres affording an effective length of 280 metres (918-ft.), width 42 metres in the dock, and 40 metres (131-ft.) at the gates.

The side walls are built up of a curtain of sheet piling of the caisson type, 20 metres long, driven at level (−15 m). The bottom of the dock is at level (−7). The level of the highest waters is (+7.15).

The crown wall in reinforced concrete which overhangs the sheet piling is levelled at (+8.15). The caisson sheet piling is anchored by means of three sets of steel ties fixed upon two hind curtains of sheet piling.

The bottom of the lock is not concreted, except near both heads, where cleaning sill 0.40 m. thick is connected to the heads at level (−8), which sill is meant to prevent the sands from being dragged in the gullies.

The cleaning sill is protected against under-pressure by means of holes 1 m2 section, filled up with stones, thus forming relief valves.

The lock heads are concrete masses founded on a reinforced concrete general culvert bottom at level (−12.50) protected against undermining by a curtain of sheet piling 21 metres long, driven at (−28 m.).

This piling penetrates into the clay stratum laying under the sands and renders the system waterproof (Fig. 10).

The reinforced concrete culvert bottom, levelled down to (−8), constitutes a huge reinforced concrete beam, able to resist the under-pressure resulting from the eventual drainage of a head.

The tail head has two gate-recesses, the first where the dock gate is sliding; the other one, fitted up as a graving dock, includes a spare gate and can be used for the repairs. The up head has only one recess. The gates can be moved at a speed of 0.20 m. per second.

4.—**Sea Wall and Reclaimed Ground.** The extension work programme included also various secondary works, such as:—

Training jetty, 218 metres (715-ft.) long, to protect ships entering the lock.

This jetty is built up of two parallel steel piling curtains, 20 to 25 metres long, spaced 6.50 metres, driven at level (−15) to (−16) and tied together by 3 rows of ties, as well as by a series of cross curtains spaced 10 metres about, from each other.

Berthing jetty, 345 metres (1,131.6-ft.) long, between the lock and the old western breakwater. Built up of sheet piling 15 metres to 28 metres long, anchored on a back curtain by means of ties.

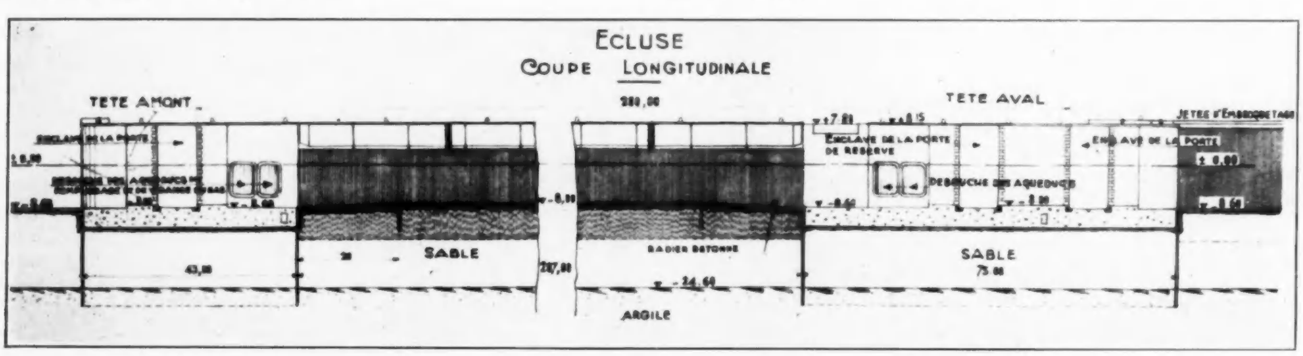


Fig. 10.

Dunkirk Harbour Extension Works—continued

Root of the 310 metres (1,016.8-ft.) long wharf, west of the training jetty, built up of steel piling from 16 to 25 metres long, tied as those already referred to, on a back curtain.

Southern sea wall, between the new western breakwater and the lock, on a total length of 845 metres (2,771.6-ft.), limiting northward the reclaimed grounds. The faces have a gentle slope (3/1), they are lined with concrete slabs resting on beams anchored in the ground by small posts. The foot of the stone bedding rests at (+3) on a concrete wall protected against sand washing by a system of steel piling 3 to 10 metres long.

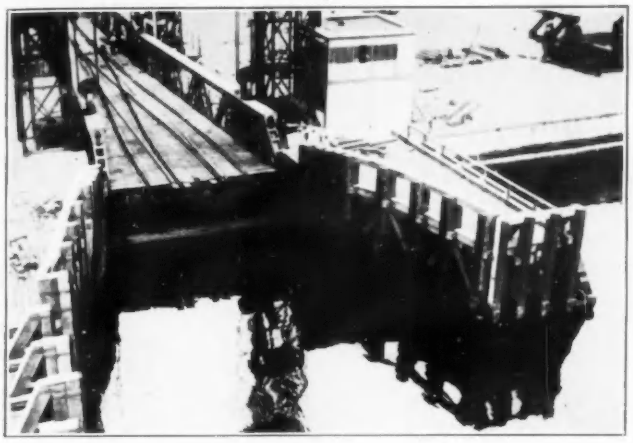


Fig. 11.

Western sea wall connecting the western breakwater to the earthen dam which protects the hinterland west of Dunkirk. It is 446 metres (1,463-ft.) long and is built up exactly as the southern sea wall.

The finishing up of the reclaimed grounds limited by the above described works, includes the refilling, building of roads, pavement, etc.

5.—**Miscellaneous Works Carried out Afterwards.** We have the main work carried out beyond:—

The foundations of the new berthing place of the Dover-Dunkirk ferry, these foundations consisting of "azobe" piles for the berthing place, properly speaking, and of concrete piles for the operating cranes, as well as the foundations themselves of the cranes (Fig. 11).

Fig. 12.

Preliminary works of the connection between the new marine lock and the harbour tidal basin, including:—

(1) Driving 270 linear metres of "caisson" steel piling 23 metres long with their ties, the whole forming three walls provided for the building up of the future entrance.

(2) Tearing down sections of the inside dock wall within which will lead the new entrance.

(3) Building an earthen dam 1,000 metres (3,280-ft.) long to provide for the protection of the hinterland against high waters in the harbour extension zone, not yet organised.

Sundry fitting works, the most noticeable of which is the lighthouse, 40 metres high, on the western breakwater head. This lighthouse will carry lights for police signalisation, night and day. They will be operated from a distance and repeated inside the harbour on special constructions (Fig. 12).

(To be continued).

Belfast Harbour Parliamentary Bill.

The Belfast Harbour Bill, which is intended to extend the powers of the Belfast Harbour Board to make improvements at the harbour, has been given a second reading in the Northern Ireland Parliament.

Cargo-Handling Equipment at Ports

(concluded from page 200)

it seems best to leave it to private interests to obtain and put such appliances into use; the Port Administration only supplying current, to meet their demand, at points conveniently arranged.

We consider that in many French ports there is much still remaining to be done in the direction of rationalisation and co-ordination of the work on the quay and the service of the cranes, thus accelerating operations and in consequence reducing overtime working, which is always costly and inefficient.

In regard to handling goods inside the sheds, when these are of more than one storey and especially in public warehouses, problems arise which cannot be left to the initiative of the tenants. Generally speaking, it is difficult to satisfy the requirements of tenants, who are reluctant to use the upper storeys. It was formerly the practice to effect communication from floor to floor by sack chutes either straight or spiral, and this enables the upper storeys to be used quite well for bagged goods.

For cases and other units having fairly uniform weight and dimensions (such as bananas, early vegetables, etc.), it is possible to use successfully conveyors with pockets or trays. On the other hand, for parcels of varying weight and size, it is only possible to use lifts and run-about cranes, machines in intermittent use and of low efficiency. All these forms of handling, moreover, have one great drawback: the lorries or wagons while being loaded or unloaded, have to stand at the level of the ground floor (which is itself, save for rare exceptions, used for storage purposes) and thus cause local congestion which has a bad effect on the usefulness of the building. So there has been an effort of recent years to construct lorry-hoists enabling road vehicles to be lifted to the upper storeys. But such lorry-hoists, even if their power is adequate, cannot be of sufficient size to carry the large road trailers which have come into use in recent years. In these conditions we consider that, whenever it can be done without excessive expenditure, it is desirable for lorries of the heaviest tonnage allowed on the roads to have access to the upper floors of sheds by ramps at a maximum gradient of 9 or 10%.

VI. Conclusion

From these enquiries, necessarily incomplete, into the complex and extensive subject of port equipment, we can draw the following conclusions:—

The equipment and especially the cargo-handling cranes and other plant in ports have by now reached such a stage of perfection that one may dismiss as improbable any new technical evolution of sufficient magnitude to affect materially the methods of transhipping cargo from ship to quay and from quay to ship. On the other hand it appears desirable that, in many ports, an effort should be made to standardise and bring the methods of handling employed on dumps and in sheds into harmony with the capacity, speed and output of the modern machines of high power and efficiency which are installed by the port authorities.

The Empire Exhibition, Glasgow

The Empire Exhibition at Bellahouston Park, Glasgow, which is to be opened by His Majesty the King on May 3rd, will contain a number of engineering and shipping features of interest to port authorities. The Exhibition is the largest of its kind since the British Empire Exhibition at Wembley in 1924. It has a substantial financial backing and will remain open until October.

The Clyde Navigation Trust are naturally taking an important part in the display with a stand in the Shipping and Travel Pavilion, and they are providing the fountain which forms a special feature in the entrance tower to the Pavilion. The principal exhibits in the stand consist of three dioramas in perspective: one of the King George V Dock area, one of the Rothesay Dock and a third showing the Queen's and Princes Dock. A model of the Meadowside Granary, partly working, is also to be shown.

Another model is being provided by the Mersey Docks and Harbour Board, showing a section of the River Mersey and the Gladstone Dock system. This will display the whole of the quayside equipment, together with a fleet of vessels entering the docks and proceeding to their respective berths.

The Shipbuilding Hall, a structure 110-ft. long by 50-ft. wide, will contain a large general diagram, 35-ft. by 40-ft., showing the actual silhouettes of all ships of over 100 tons gross register launched from British yards during 1937.

At a later date it is proposed to give a fuller account of the exhibits which are of interest from a port point of view, and a report of certain papers on port subjects to be read at the International Engineering Congress, which is to be held at the Exhibition towards the end of June.

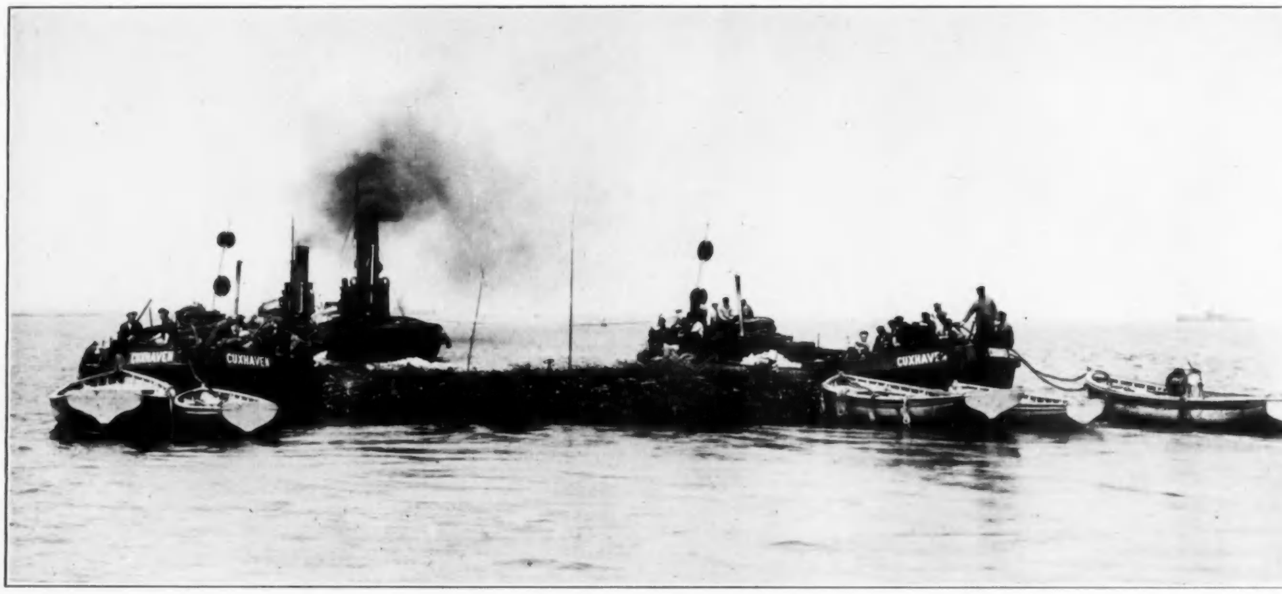
German Inland Waterways and Harbours Developments during 1937

(Translated from the official Report of the Reichsverkehr-ministerium).

(continued from page 181)

II—Seaports

The accommodation and plant erected at harbours must always endeavour to keep, to a certain extent, ahead of the anticipated requirements. Only by so doing can the harbour hope, with any prospect of success, to cope with the traffic and financial problems it will encounter, and more particularly to develop the peak efficiencies that are, in emergencies, called for and be prepared to meet the increasing stress of traffic requirements without undue delay.



Mattress Work in the Lower Elbe.

Emden

The harbour of Emden has, since the year 1931, displayed an extraordinary development in activity. The total turnover figures were:—

1931	3,022,000 tons
1932	3,886,000 ,,
1933	5,171,000 ,,
1934	7,182,000 ,,
1935	7,949,000 ,,
1936	9,640,000 ,,

The gigantic growth in traffic could be successfully dealt with only by epxloiting the available harbour resources to their very utmost, an in order to be prepared for a future increase in the traffic volume, a beginning was made in 1936 in extending the facilities and capacity of the harbour. These extensions comprise the enlargement of the inner harbour for the mass transfer of cargo as also the laying out of the grounds for wharves, rail-tracks, and assorting and despatch sheds. It is intended to speed up the work so that the enlarged installations may be ready for service by the Spring of 1939 at the latest. The extensions and renovations will involve a total expenditure of approximately 6 to 7 million Reischmarks.

Wesermünde and Cuxhaven

The fishing harbours of Wesermünde and Cuxhaven have acquired an extraordinary importance in view of the food supply problems arising under the Four Years' Plan. The increase in the quantities of fresh fish landed at these two harbours is sufficiently evidenced by the following statistics:—

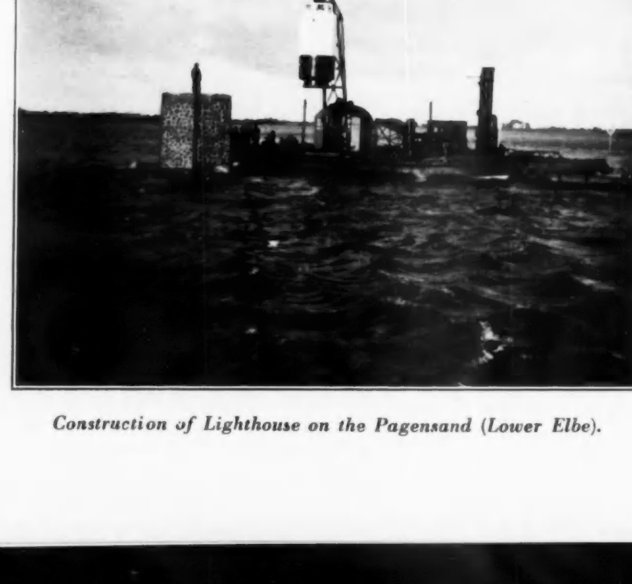
	Wesermünde	Cuxhaven
1931	130 mill. kg.	74 mill. kg.
1932	128 ,,	72 ,,
1933	145 ,,	70 ,,
1934	146 ,,	64 ,,
1935	182 ,,	80 ,,
1936	227 ,,	107 ,,

As the deep-sea fishing steamer fleets of Germany have recently multiplied beyond previous proportions and made correspondingly increased demands on the fishing harbours, it is imperative that steps be taken in good time, to ensure the harbour extensions called for. To this end, the extensions already in progress in Wesermünde were, in 1937, still further accelerated. Similarly the fishing harbour of Cuxhaven which on April 1st, 1937, passed under the administration of Prussia, underwent renovations and enlargements. The new undertakings in both harbours comprise the fitting out of the requisite docks and water channels, the building of quay walls, of auction and packing halls, the construction of road and rail tracks and the provision of facilities for dispatch. The costs for the extension of the two harbours are provisionally, estimated at a total of roughly R.M. 15 millions, and the work is to be speeded up so that the harbours will be available for service, by the end of 1939, if possible.

Büsum

The Four Year Plan also stipulates that the fleets of German deep-sea fishing cutters shall be multiplied on a similarly generous scale and this renders an extension of the fishing harbour of Bosüm which devotes itself, preferably, to deep-sea cutter fishing, an urgent necessity. The undertaking was already taken in hand in the course of 1937 and will involve an expenditure of approximately 5 million Reichsmarks. In this case also the operations, which include the construction of two harbour basins along with the appropriate quay surface, road and rail ways and dispatch sheds, the building of two harbour piers to ensure free ingress and egress for the cutters and the installing of protective dock gates, are to be accelerated so that it will be possible to put the enlarged harbour in commission by the end of 1939. A further motive instigating this extension of Bosüm fishing harbour is that of effectively counter-working the ever keener competition arising from the Danish harbour of Esbjerg.

In view of the somewhat formidable difficulties, experienced during 1936, in the " corridor " traffic to and from East Prussia, the problem arose of how to real with those goods' cargoes which, during this interval, had to be conveyed by sea and to have them transferred, in steadily increasing volume, in the harbours of Königsberg, Marienwerder, Elbin and Stettin whenever any such



Construction of Lighthouse on the Pagensand (Lower Elbe).

German Inland Waterways and Harbours Developments—continued

difficulties recurred. In order to guarantee the smooth development of this sea-traffic, a start was made in enlarging these harbours, in providing them with more extensive transfer plants and accessories and in equipping them with the requisite buildings and outfit.

Pillau

The same tale has to be told of the harbour Pillau which, of late years, was no longer able to cope with the increase of traffic. The quay areas of the rear dock, where the cargo transfer between ship and rail was effected till a few years ago, had to be commandeered for other purposes. Furthermore, the traffic arising from the mercantile marine and passenger transport of the shipping service of East Prussia grew by such leaps and bounds, that the operating conditions steadily became more and more strained and the enlargement of the harbour became inevitable. A start was made with the work in the beginning of the year.

Junction of the Midland Canal with the Elbe.

Sea Waterways, Island and Coast Protection
The Kaiser-Wilhelm Canal

In the course of the year a considerable amount of sand was deposited in the canal and the depth available for navigation was thereby lessened. So far this drawback had simply to be tolerated. But the canal when widened and improved, has acquired such an unprecedented importance for mercantile shipping, the number of vessels and the volume of goods passing through the canal have shown so steady an increase and more particularly, the number of large and deep-draught ships utilising the canal has multiplied so steadily from year to year, that the restoration of the original " Soll " depth of 11.33 metres had to be undertaken. This will take roughly two years to complete.

Gieselau Canal

Between the Eider and the Kaiser-Wilhelm Canal a new communicating canal of approximately 25 kilometres ($18\frac{1}{2}$ miles) in length and extending below Rendsburg—called the Gieselau Canal—has been constructed and was thrown open for traffic in August, 1937. The canal, which includes a lock of 70 metres in length, $9\frac{1}{2}$ metres wide and $3\frac{1}{2}$ metres deep, shortens the shipping route between the Elbe and Eider harbours by about 50 kilometres (31 miles). The former Rendsburg lock which previously served to join up the Eider with the Kaiser-Wilhelm Canal has been filled up, and the municipality of Rendsburg has taken advantage of this to improve its town planning amenities. Furthermore the railway swing bridge crossing the old lock canal on the track of the main line Hamburg-Neumünster-Flensberg, can be removed.

The Elbe Below Hamburg

It is proposed that the Lower Elbe, between Hamburg and Cuxhaven shall be deepened to a depth of 10 metres below normal weather sea levels [" M.Spr.N.W."]. At two localities in the course of the river, namely, at the Island of Pagensand and in its course between the outlet of the Kaiser-Wilhelm Canal at Brunsbüttelkoog and its eastern outlet, this undertaking encountered, in consequence of natural changes in the river's course, considerable difficulties which, in spite of protracted and expensive dredgings, could not be overcome. Hence the Reich, since it took over the administration of the waterways in 1921, has extended and assigned boundaries to both river stretches by an elaborate system of control, involving an expenditure of approximately 35 million Reichsmarks. These control measures connected with the extension have, to all intents and purposes, been settled and have proved a complete success.

The Weser Below Bremen

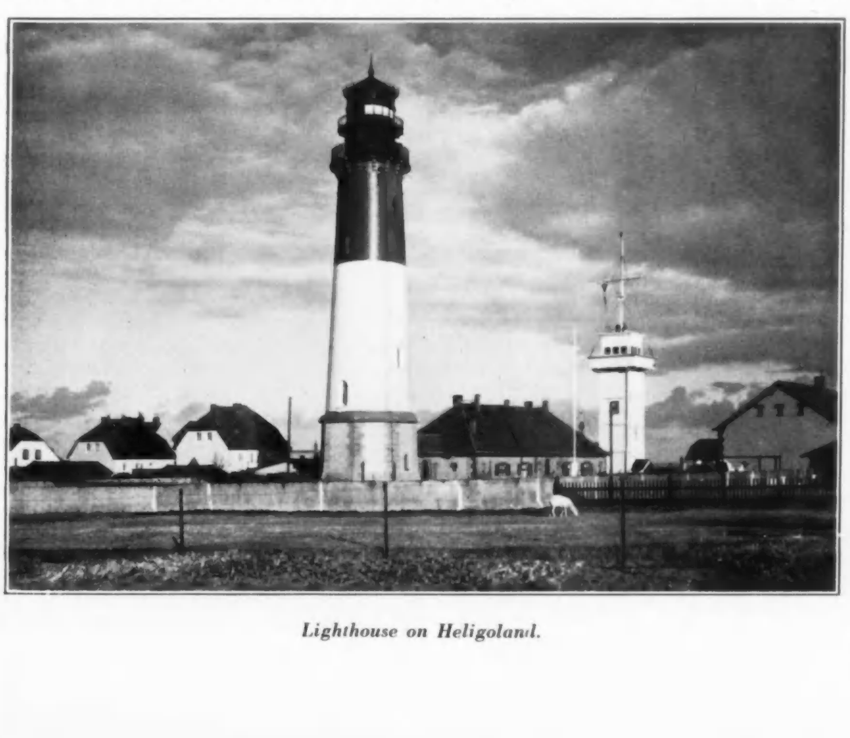
On July 19th, 1937, the 50th anniversary of the day on which Ludwig Franzius, Chief Constructional Consultant of Bremen, turned the first sod for the now famous Lower-Weser rectification, the event was festively commemorated (in the presence of Dr. Ing. Dorpmüller, Traffic Minister for Germany and Prussia).

The extension of the Lower Weser has been carried out in four stages. In the period 1887-1895, Franzius adapted it for vessels of 5 metres draught and during 1913-1923 it was further improved to accommodate vessels of 7 metres draught passing through Bremen. The State subsequently continued the extension work till 1925 and completed the development by a final fourth extension in 1925, designed to allow passage to vessels of 8 metres draught. This extension is now completely finished. It has rendered the harbour of Bremen town accessible for the world's traffic under highly favourable conditions and has reinstated Bremen in its position as a leading trade centre, thus also safeguarding its future.

The Island of Borkum

In 1921, the State took over, on the North Sea Coast, the defence of the island of Borkum at Wangeroog, in addition to the island protection control till then carried out by the province of Oldenburg.

The west corner of Borkum is exposed to very violent attacks from tempests, the inclemency and virulence of which seem to have gained in intensity with the years, so that the island protection devices as at present organised and consisting of an encircling rampart of dunes and a large extent of camp sheeting are no longer adequate. More particularly there was a certain deep indent in the island coast, the so-called beach-gorge and its continued advances imperilled the very existence and stability of the operations and the installations on the edge of the island. The State has taken in hand the task of re-casting the form and dimensions of this gorge. To this end four of the camp sheeting, already extant, have been extended some 2-300 metres, and further risk is, presumably, obviated. With a view to facilitating the operations undertaken for coast reclamation—and welcome evidences of success in this are now already perceptible—three further barricade extensions were started on in the year 1937. Furthermore, in the same year, a first attempt was successfully made in the erection of a submarine parallel breakwater in two series of barricades at approximately the level of the former barricade tops and intended to reduce still further the difficulties of the undertaking.



Lighthouse on Heligoland.

The dune-protection rampart which after withstanding the severe shocks from storm and tide in the autumn and winter of 1936, had been partially destroyed, has now been restored over a stretch of some 200 metres. Moreover, a more effective outline—an S-outline—has been given to the new breakwater, this form having been arrived at from observations made on the line of attack favoured by the breakers.

The Baltic Province of Pomerania

The improvement of the waterway between Stettin and Swinemünde has this year been

German Inland Waterways and Harbours Developments—continued

Mattress Work in the Lower Elbe.

completed by supplementary operations for the stabilisation of the banks and strengthening the flushing surfaces so that vessels of 8 metres draught can now reach Stettin even at low tide. In Stettin harbour also, space has been provided for larger vessels to turn and reverse their routes.

In Pomerania, the barricade system for coastal protection has been further developed at Kolpinsee and on the Island of Hiddensee. In order to reinforce the north side of the Hiddensee, the steep banks of which are dilapidating, a commencement has been made in erecting protection devices (a stone wall and barricades). By these precautions, it is hoped, not only to preserve intact the exceptionally charming landscape attractions of the island, but also to protect and safeguard the Dornbusch Lighthouse, with its alarm signals for fog and tempest and, finally, to protect Rügen and the important Bug peninsula.

Special interest attaches to the improvements made in the channels for vessels approaching Stralsund by large-scale dredging operations, as this will ease the congestion in the eastern arrivals passing via the brick works and the swing bridge on the Rügen dam. The material brought up by the dredger is, advantageously, cleansed on the trestle support and, subsequently, serves to reclaim new ground which is useful in protecting the approach channels for vessels.

Completed Lighthouse on the Pugensand.

Baltic Province of East Prussia

The gigantic augmentation within recent years in the traffic from and to East Prussia has rendered it imperative to enlarge the Konigsberg sea canal to two-ship width. The undertaking was initiated by starting, provisionally, with the stretch from Pillau to Peyse. The building period was, temporarily, fixed at four years.

Sea Signalling

In the department of sea signalling, the technical advances made have enabled progress to be realised in conferring greater security on shipping during darkness and fog and an entire series of improvements have been effected. Thus a number of the more important beacon lights on the coast were amplified by introducing electric, high power, incandescent lamps; wherever arc lamps for general utility purposes, which betray many defects when employed for lighting, were in service, they were replaced by gas-filled incandescent lamps having luminous elements of a special construction. After replacing the last of the beacons still used on the German coasts which emitting an antiquated and readily misleading medley of signals, by a system of unambiguous flash-or-twinkle signals a desideratum long wished for in shipping circles has been realised. As part of the change-over to electric operating of the signal beacons, diesel electric current generators have been installed in several plants, which function throughout the whole night without supervision and which, in the event of a breakdown, automatically switch over to a second diesel plant.

In the department of fog signalling, a number of antiquated wind-and-fog-signalling plants operating with compressed air have been replaced by up-to-date electric diaphragm transmitters of great sound intensity. For wireless signalling as an important stand-by for the seafaring during fog, a transmitter for quartz control has been evolved and put in operation, experimentally.

During the days July 5th to 10th, the Third Inter-State Conference of Marine Signalling Directors took place in Berlin. In both the plenary and departmental sessions, interesting problems of general interest, bearing on light beacons, fog signalling and wireless transmission, were discussed. No fewer than 67 technical scientific papers (27 being from Germany) were read dealing with various specialised subjects, and forming the basis for the discussions that followed. The delegates participating numbered 115 in all and represented the following countries:—

The Argentine, Belgium, British-India, China, Denmark, Germany, England, Esthonia, Finland, France, Holland, Ireland, Italy, Latvia, New Zealand, Norway, Scotland, Sweden, South basis for the discussions that followed. The delegates were officially welcomed on July 8th by the German and Prussian Minister of State for Traffic.

After the conclusion of the discussions in Berlin, the conference delegates set out, the following week, on a tour of inspection of

German Inland Waterways and Harbours Developments—continued

the marine signalling plants of Germany which took them via Stettin, Swinemünde, Rügen Rostock, Kiel and Hamburg to Cuxhaven.

Vessels and Instruments

In the acquisition of control vessels for the State Waterway Administrative Board, special stress was laid, as in former years, on the desirability of using native fuel-materials to run the vessels. Thus a great number of new tugs came into being which were equipped with suction gas generators or high-pressure steam plants. The operating fuels employed in the suction gas plants comprised anthracite, distillation lignite coke, or wood and the experience so far gained goes to show that this new system of operating is, with inland ships, economical and capable of development. Coming to marine vessels, a remarkable new construction is presented in the fourth passenger ship for the maritime service of East Prussia as also in the building of two ice-breakers for the Kaiser-Wilhelm Canal and the Kurische Haff. All three of these are still on the stocks. In order to make a further reduction in maintenance costs of the vessels and instruments in service with the State Waterways Administrative Board, the building yards and State wharves were enlarged and equipped with an up-to-date set of engines, and instruments.

The Ship Building Experimental Station in Hamburg received several orders for research work relating to stability and vibrations and carried out a series of experiments on model ships representing State-owned vessels.

Port Administration in the United States

*Report of Committee of the Americen Association of Port Authorities on Port Administration and Finance**

The subjects assigned to the Committee on Port Administration and Finance for the year, were as follows:—

1. Methods of Financing Port Development and Operation.
2. Survey of Port Departmental Administration and Organisation.

Questionnaires were sent to all of the members of the Association, and up to this time replies were received from twenty-four ports.

The first subject, " Methods of Financing Port Development and Operation," was divided into four sections. 1. Sources of Funds for Expenditures for Administration, Operation and Maintenance. 2. Sources of Funds for Capital Expenditures for Construction, Port Development and Major Equipment. 3. Sources of Funds for Interest Charges on Funded Debts or Loans. 4 Sources of Funds for Retirement of Funded Debts or Loans.

Operation and Maintenance

From the analysis of the questionnaires returned, it was found that sixteen ports out of twenty-four, finance expenditures for administration, operation and maintenance exclusively from the revenues of the port. In one instance, the revenue of the port is sufficient to pay all of the expenditures, including interest and sinking fund charges, but the revenue is paid into the general fund of the political subdivision, and is reappropriated to the port. In three cases these expenses are paid by a combination of port revenue and general taxation; in two cases, from general taxation exclusively; in one case from revenue and land rentals; in one case from revenue, general taxation, land rentals, and oil royalties; and in one case from general taxation and private subscriptions.

New Works

For capital expenditures for construction, port development, and major equipment it was found that in ten cases out of the twenty-four, these expenditures are financed from a combination of port revenue and the proceeds of bond sales; in four cases they are financed exclusively from the proceeds of bond sales; in two cases from general taxation; one port finances these expenditures from a combination of revenue, general taxation, and bonds; one from revenue, general taxation, bonds, and the proceeds of the sale of port revenue notes; one from revenue bonds and subsidies; one from revenue bonds and land rentals; and one from general taxation and bonds. Five of the ports report having received Federal grants.

For interest charges on funded debt or loans, the questionnaires showed that in seven cases these expenditures are financed from port revenue; in nine cases from port revenue and general taxation; in six cases from general taxation; and in one case from revenue and gasoline taxes. One of the twenty-four ports did not report.

For retirement of funded debt and loans, seven of the twenty-four ports reported that these payments are made exclusively from the revenue of the port; eight from revenue and general taxation; seven from general taxation; and one from revenue and gasoline taxes. One port did not report.

A summary of the above information shows that the funds for expenditures for administration, operation and maintenance, in the majority of cases, are derived exclusively from port revenue; that the funds for capital expenditures are, generally speaking, received from three sources: Port revenue, bonds, and general taxation; and that funds to cover interest and retirement charges on funded debt and loans, are produced in most cases from a combination of port revenue and general taxation.

Organisation

The second subject assigned to the Committee, " Port Departmental Administration and Organisation," is much more complicated, and will require further study before a complete detailed report can be submitted. However, the data so far secured gives a general idea of the organisation of the twenty-four ports reporting.

Nineteen of the ports designate the governing body as either a Board or Commission. One is administered by a Bureau of Harbours; one by a Port Authority; one by a Department of Parks and Public Property; one by a municipal terminal body; and one by a combined city and state Board.

These bodies are selected as follows: Eight are appointed by the Mayor of the city; five are appointed by the Governor of the state; three are elected by the voters of the port district; two are elected by stockholders (these are privately operated terminals); two are elected by the voters of the city; one is a combination—three of the members being elected by the voters of the city, four being appointed by the City Council. In one instance two members are appointed by the City Council, two by the County Supervisors, and one by a joint committee of the two bodies. One is composed of a committee of city officials; and in one case, there is a dual body—one acting in an advisory and regulatory capacity, the other being a managing and operating entity. The first is a combined state and county board, two of the members being appointed by the Governor, and three by the Mayor of the city. The members of the second body consisting of three, are appointed by the Governor.

The number of members of these governing boards range from one to twelve. In eight cases, there are three members; in eight cases, five members, two are composed of seven members; two of eight members; one of a single member; and one of twelve members. Two of the ports did not report.

The terms of the members of the governing boards present a rather strange coincidence in numbers—in one instance the term is one year; in two instances, two years; in three instances, three years; in four instances, four years; in five instances, five years; and in five instances, six years. In one case, the members serve at the pleasure of the Governor, the appointing power. Three of the ports did not report.

In sixteen of the ports the members of the governing boards are unpaid. In five ports they are paid. Three of the ports did not report.

In nineteen of the twenty-four ports reporting, there is an executive officer, not a member of the governing body, who is responsible for the general management of all departments. The titles range from General Manager, Port Director, Port Supervisor, Port Agent, Manager and Secretary, Port Director and Engineer, General Manager and Chief Engineer, to Harbour Engineer. In four of the ports, the general management is in the hands of the Chairman or President of the governing board, and in the case where a dual body exists, the managerial duties are divided between the Vice-Chairman and Secretary of one body, and the Commissioner of Public Works of the state.

There is such a diversity among the ports in the designation of departments below the executive officer, and the functions performed, that it is impossible at this time to give a detailed account of the major departments which exist at the various ports. This would require an organisation chart with a description of the powers, duties, and functions of each department at each port. Generally speaking, however, the following departments will cover the whole field: Finance and Accounting; Purchasing; Rentals and Real Estate; Traffic, Rates, Solicitation and Public Relations; Legal; General Operation of Piers, Wharves and Terminals; Operation of Railroads; and Engineering, including Designing, Drafting, Testing, Inspection, Construction and Maintenance.

The Report was signed by Messrs. M. H. Gates, Chairman; Alex Gray, Vice Chairman; John E. Ramsey, J. Russell Wait, John McKay, and Collins B. Allen.

* Presented at the 26th Convention of the Association at Wilmington, Delaware, U.S.A., October 13th, 1937.

*Bhavnagar, India's Newest Port**

By Lt.-Col. B. C. ALLIN, Director and Chief Engineer of the Port of Stockton, California, U.S.A., Consulting Engineer to the Bhavnagar State, India

The Port of Bhavnagar, lying on the eastern shore of the Kathiawar Peninsula on the West side of the Gulf of Cambay, on the West Coast of India, presents a number of interesting, and even unique, features.

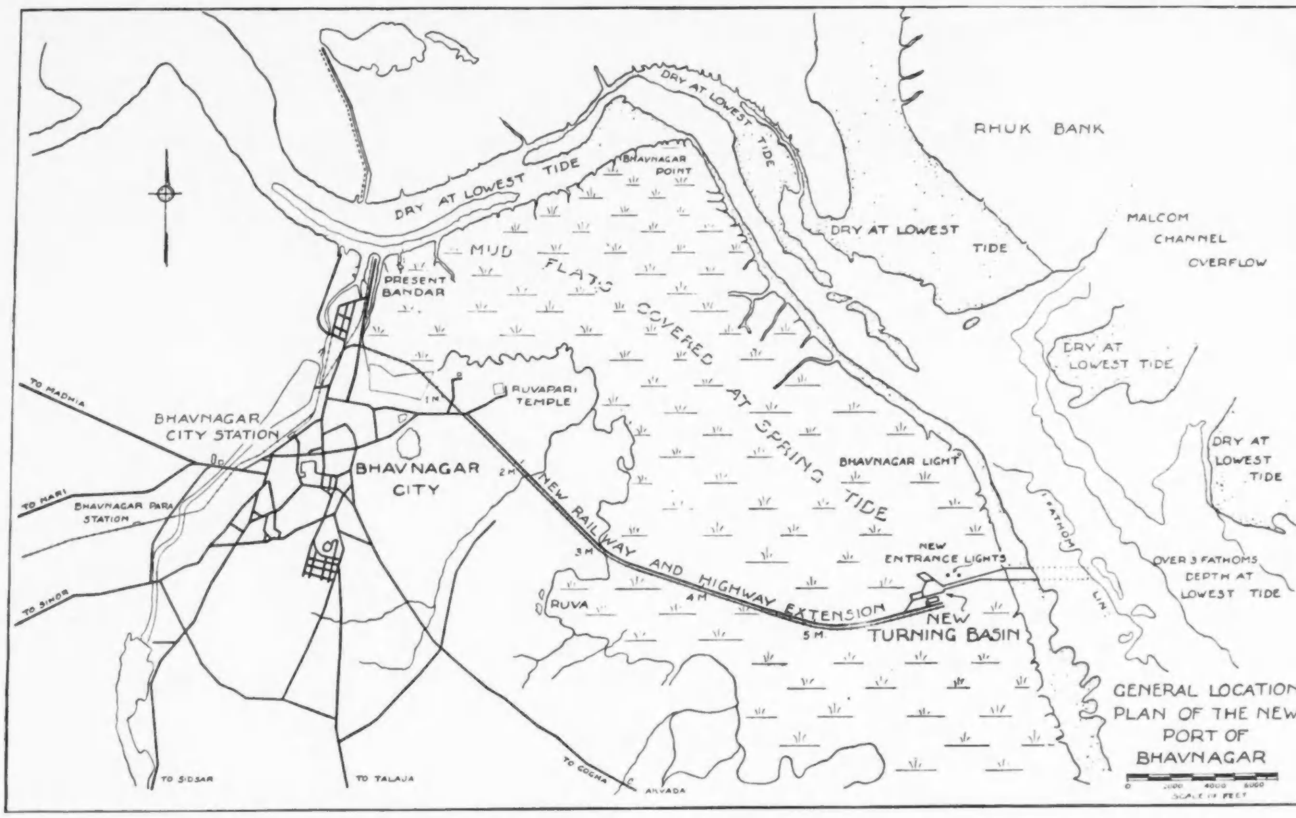
The Gulf of Cambay, which is little known outside of India, is the seat of the earliest commerce of Europe with this fascinating Empire. About 1500 A.D., the Portuguese made their first visit to India, and about ten years later established their capital at Goa on the West Coast of the peninsula. Slowly the Portuguese influence moved northward up the coast and eventually reached the peninsula of Kathiawar.

The railroads from Bhavnagar and Bombay serving the north central portion of India join immediately north of the head of the Gulf of Cambay, and Bhavnagar has an advantage in being 139 miles nearer to this junction than is Bombay, thus giving it a mileage handicap over Bombay in the serving of a tremendous interior section of the country.

Probably the largest factor in the delay of Bhavnagar in developing its port has been the peculiar condition in the Gulf of Cambay.

This Gulf has a length from north to south of approximately 100 miles. The width of the entrance is about the same, and on two-thirds of the way inland it has a width of from twelve to twenty miles, which width continues to the innermost limit.

A number of rivers tributary to the Gulf have caused very considerable silting, so that a large portion of the interior section of the Gulf has already filled up to above sea level and large mud flats, miles in extent, are spread about the centre of the estuary.



GENERAL LOCATION PLAN OF THE NEW PORT OF BHAVNAGAR

The English, meanwhile, became interested in trading with India, and finally in 1609, the first British ship "Hector" dropped anchor at the Port of Surat in the Gulf of Cambay—the first British vessel to anchor at an Indian port.

From this time henceforward for many years a very considerable trade ensued through the ports on the Gulf of Cambay, during which time Bombay, which was a group of seven islands located on the bay of that name, developed into a considerable harbour, due to its natural advantages.

Bhavnagar is first mentioned as a port in the early part of the 18th century, and has for more than 200 years been a port with an interesting history behind it.

From a political standpoint, the Port of Bhavnagar is one of considerable interest, in view of the fact that it is in one of the Native States and not in British India. Many years ago the State of Bhavnagar arranged a commercial treaty with the British Government whereby, for concessions granted, it was given the right to develop its port and collect its own customs revenues, which, however, according to the treaty, must be the same as are collected by the British ports.

As a consequence there is a considerable difference between Bombay and Bhavnagar, and the competition which exists, for example, among American ports, where the only incentive in port development is the collection of port dues and the general advancement of the community, while in this case in India there is the customs revenue, which for the year 1930 amounted to approximately 1⅝ million dollars at Bhavnagar.

When goods are imported into India through Bombay, the British Indian Government gets the customs revenue irrespective of the point in India to which they are consigned, whereas when goods are imported into India through Bhavnagar, irrespective of the point in India they reach, the State of Bhavnagar gets the revenue.

* Reproduced with revision from the Bulletin of the Permanent International Association of Navigation Congresses, No. 23, January, 1937.

The most unusual condition present in the Gulf, however, is that of the tides. A tidal force which has its node in the vicinity of the Lacadive Islands reaches its maximum at Bhavnagar. This tide, which at the entrance of the Gulf reaches a height of probably 14-ft. at Bhavnagar, reaches a maximum of over 39-ft. on spring floods and a minimum height on neap floods for the year 1931 of about 23-ft.

The present Port of Bhavnagar is situated on a creek of the same name, approximately six miles above its entrance into a larger estuary, whence it is approximately six miles more to the main open Gulf.

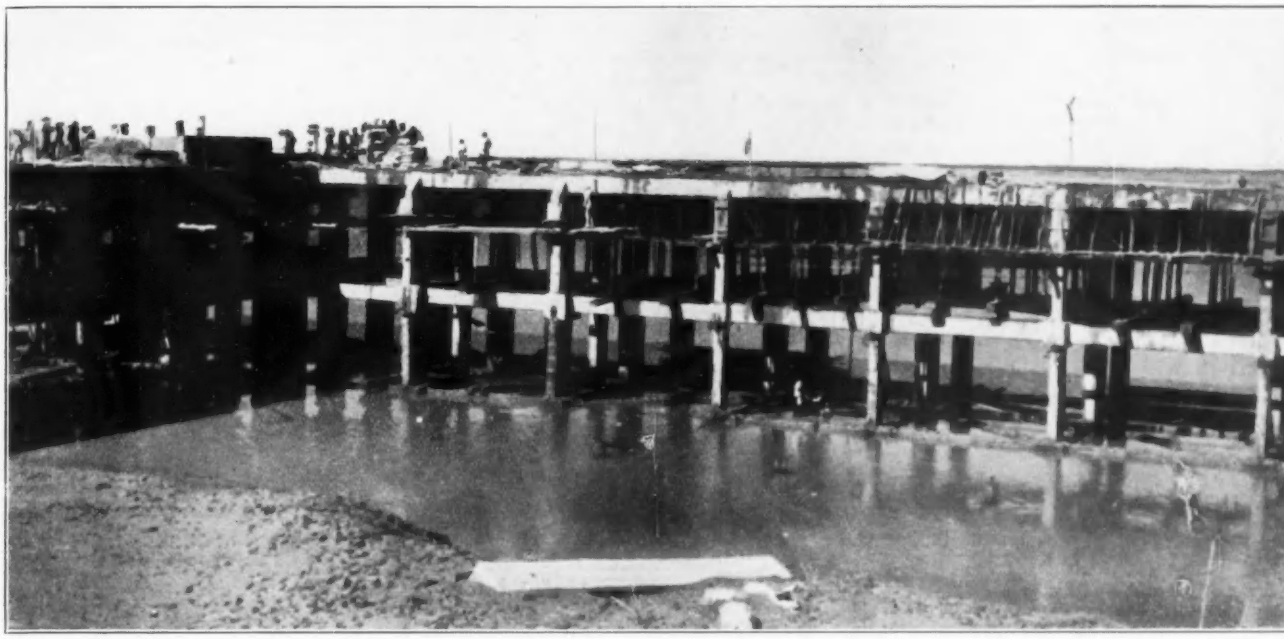
The creek, although silted up to above low tide in most sections, has the appearance of a Mississippi on high tides and the extreme tidal action causes a current of from 5 to 6 knots. The drainage area of the creek brings into it a fine silt which with the tidal section is moved up and down the creek in suspension, the water containing at times as high as 11 per cent. solid matter.

As a result of the deterioration of the creek the State of Bhavnagar has obtained reports from a number of European engineers during the past 25 years. Some of these people held the opinion that Bhavnagar should be abandoned entirely as a port, and others advised a dredging programme in the river in spite of the handicap.

During this period, while the State has been hesitant as to the best course to pursue, the deterioration has been so great that vessels handling overseas cargo have stopped coming into the creek and have remained at anchorage in the entrance, the cargo being transported by lighters for a distance of from 8 to 12 miles to the docks.

This, accordingly, was the situation which confronted me when I was called in to advise and report in 1931, and it seemed most desirable that a solution to this difficult situation be obtained, making possible the continuity of service of Bhavnagar as a port, in view of the strategic position it holds and its advantages in this regard over other possible port locations in the State, and also due to the fact that it is the capital

Bhavnagar—continued



Main Jetty between Road Approaches 1 and 2, 14th January, 1936.

of the State and a commercial centre of considerable importance.

Study was given to conditions in the Gulf of Cambay, a very convenient basis for this being the Royal Indian Marine Surveys of 1886 and 1926, furnishing a forty-year contrast.

The major tidal force swings into the Gulf of Cambay from the south-west, running along the shore of the Kathiawar Peninsula fairly close to the shore line and passing Bhavnagar approximately six miles from the entrance to the creek.

It was consequently plain that the water at this location would be safe from deterioration for centuries to come, and that the only critical point would be the six-mile stretch—and the creek. The country between the city and the shore line at the mouth of the creek—six to eight miles distant—is comprised of level mud flats, which are covered with from 2 to 4-ft. of water at very high spring tides.

The tidal current flowing out of Bhavnagar Creek sets away from the shore line diagonally, leaving a triangle of slack water between the major tidal force of the Gulf of Cambay and the shore line. Study developed that the depth of water in this triangle has not materially changed in 40 years.

Consequently, it seemed certain that if a port could be located in the tidal flat near the open water and abandoning completely the Creek which is deteriorating, the problem would be solved for a century or so.

Map showing the location of the Port of Bhavnagar.

These tidal flats have an average elevation of 28-ft. above low tide, and due to the tidal range it was decided to construct the wharf and warehouses at an elevation of 42-ft. above low tide.

Boring operations were taken at a point about five miles from the city and one mile inside the actual shore line, to determine the nature of the soil, and the result showed a sandy silt which seemed well adapted to any reasonable dredging programme. It was consequently decided to develop a port through the medium of a dredged channel, dredging it to 6-ft. below low tide, thus giving approximately 29-ft. of water through the channel at the lowest high tide in the year.

The entrance section of this channel in the open water required dredging for a short distance of approximately 3,400-ft. before the actual bluffs of the shore were reached. This section was laid out with a width of 500-ft., the dredging being a very shallow cut, running from nothing to a maximum of 10-ft. at the shore. The channel itself inside the shore line was laid out with a bottom width of 100-ft. and slopes of three on one, and at the interior end was laid out a turning basin to be used for the construction of wharves and facilities and for the turning of the vessels.

One side of this turning basin was designated as the initial wharf section, along which the first docks were to be constructed, and this section was prescribed to be dredged to a depth of 28-ft. below lowest tide on a 100-ft. width, in order that vessels while lying at the wharf might at all times remain afloat, although they would enter and leave the port only at high tide.

The material obtained from the dredging provided fill for the reclamation of the port area around the turning basin, a fill of an average of 12-ft. being required for this. Extending along both sides of the channel and at a distance of several hundred feet from it were provided protection levees to be pumped up without retaining levees with a minimum top width of 200-ft. at an elevation of 6-ft. above the highest high tide.

It was naturally concluded that there would be a certain amount of silting in the turning basin, especially in the deep section, and also at the channel outer entrance, but in view of the fact that the channel entrance was in slack water which had not shown a tendency to fill in 40 years, and also in view of the fact that the tidal prism in the artificial channel and the turning basin was extremely small, it was well expected that this would not prove burdensome, certainly not as contrasted with what the State had been experiencing.

An interesting feature was prescribed with reference to the method of dredging. Due to the tidal fluctuation, it was desirable to devise a method whereby the capital programme could be prosecuted without the dredging plant remaining stranded at low tide, and consequently it was provided that the dredge would commence work at the shore line, and at high tide, and would dredge an initial narrow entrance cut into the bank not lower than 13-ft. above minimum low tide. Proceeding with this inland for a distance of some 500-ft., the dredge would then proceed to cut the channel with full width and depth, leaving the 500-ft. section as a natural dam which would always during the progress of the inside work assure a depth of 19-ft. of water in which the dredger would work, while at the same time, fuel barges and other auxiliary craft could enter the channel at high tide.

Bhavnagar—continued

The very unusual silting effect which pertains in this locality could be determined in its effect on the project only by very careful study with a proper hydraulic model, but these facilities not being immediately available, certain phases of the work were to a certain extent experimental, among which was the question of the sill.

Mr. Moorehead, who was appointed Manager and Advisor of the Bhavnagor State Ports and carried out the work under my direction, found that with the sill at the height originally contemplated the silt content, which is normally 0.85, became much greater, and consequently interfered with the condensers of the dredges, and he found it desirable to lower the sill during the process of construction. This, with beneficial results, was accordingly done, the sill being lowered to a point where flotation of the dredging plant would have been reduced.

It may reasonably be expected that a wharf to serve a wet dock having a 39-ft. range of tide would be somewhat unique, and as a matter of fact, the wharf rises 70-ft. from the mud line to the deck. The initial structure has been prescribed with a length of 600-ft. minimum with provisions for further extensions in the future, and is to be designed for a live load of 300 lbs. to the sq. ft. in addition to railway and crane loads.

The actual length of the wharf as determined by Mr. Moorehead is 882-ft.

The existing wharf at Bhavnagar is of steel construction and resting on screw piles, being designed for a live load of 200 lbs. In the present case, screw piles were not recommended, inasmuch as the full weight of the structure rests upon the screws, whereas with friction piles the weight is taken up by the entire section of the pile which penetrates the ground, and the added height and loading desired were not considered desirable for screw piles. Accordingly, an open concrete pile structure was recommended.

The initial shed construction consists of galvanised iron buildings, 80,000 sq. ft. in area, located in the rear of the wharf and designed for transit cargo only, the existing group of warehouses at the old port continuing to be used for the storage of goods in bond. Three approaches will connect the wharf with the shed, and tractors and trailers are prescribed for the handling of cargo between the shed and the jetty, the three approaches making transportation over these possible in continuous loops either when one or two ships are working simultaneously and thus avoiding congestion.

One matter of concern was the mooring of the vessels subjected to a tidal variation as high as 40-ft. It is obvious that unless some provision were made, a gang of men would be required to remain on duty practically constantly adjusting the lines of the vessel, where the elevation varies as much as 7-ft. in an hour.

Consequently, there was designed a contrivance called, for want of a better name, a Mooring Stabilizer. These will be installed in addition to ordinary bollards, which will be used during unusual weather conditions, and they will be placed at intervals of approximately 100-ft. along the face of the wharf.

This stabilizer consists of a simple vertical slot running from the deck of the wharf down to an elevation of 10-ft. below low tide. They are very simple in design and are built up of steel plates and Z bars. The slide in the slot is constructed of plates to which the mooring ring is fastened, and to which the ship's lines are attached. This slide is always kept 2 or 3-ft. above the surface of the water by light steel tanks which support it and which slide up likewise, attached to the slot. This keeps the ship's lines automatically at the same tension and relationship to the mooring, irrespective of the elevation of the water.

Looking East from Number 2 Road Approach, 8th February, 1936.

The detailed surveys—topographical and railway—as well as all the drafting work, were done by native engineers, for the most part graduates of the various Indian institutions.

The estimated cost of this initial major programme to be undertaken by the Bhavnagar State is slightly in excess of one and one-half million dollars, and it is felt that on account of the above mentioned unique features, it will present a very interesting example of modern port development in the Orient.

Interesting deviations from the tentative plan originally contemplated have been found necessary by Mr. Moorehead. The channel slope was figured on the 3 to 1 basis with protection levees set quite a distance in the rear to allow a berm in case the material did not prove practical at this slope, and actual experience has found that the slope is approaching a 1 to 4 or 1 to 5 angle.

In spite of the borings which were taken for the deeper portion of the turning basin, clay bolders and hard pan were encountered which interfered with the driving of the piling, and consequently, as a lack of sufficient penetration was obtained, a short bulkhead 5-ft. high is being placed along the face of the jetty, made up of precast sections bearing against piling, in order to hold the toe of the slope of rip-rap which will be filled in to a corresponding depth around the piling and up the slope.

The content of silt is quite heavy in the turning basin, and experiments have been carried out by Mr. Moorehead with a view to ascertaining the practicability of a shore-pumping plant with fixed pipe of 40-ft. centres for the purpose of eliminating at a minimum expense the major portion of the silt from the deep section of the turning basin.

A power plant has been constructed about 3½ miles from the port for the purpose of supplying electric power, and adjacent thereto a water well has been sunk, and a tower 100-ft. high, holding 100,000 imperial gallons, has been constructed for obtaining the necessary storage and pressure.

The formal opening of the new port took place in the latter part of 1937.